Graphics • BASIC • C • Modula-2 • Pascal • COBOL

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The Resource Journal for IBM Micro Programmers

PROGRAMMER'S Journal

JANUARY/FEBRUARY 1989
Volume 7.1
$5.00 Canada $6.25

Graphics

VGA Programming in 256 Colors

Graphics Coprocessors from TI and INTEL

More Windows Programming

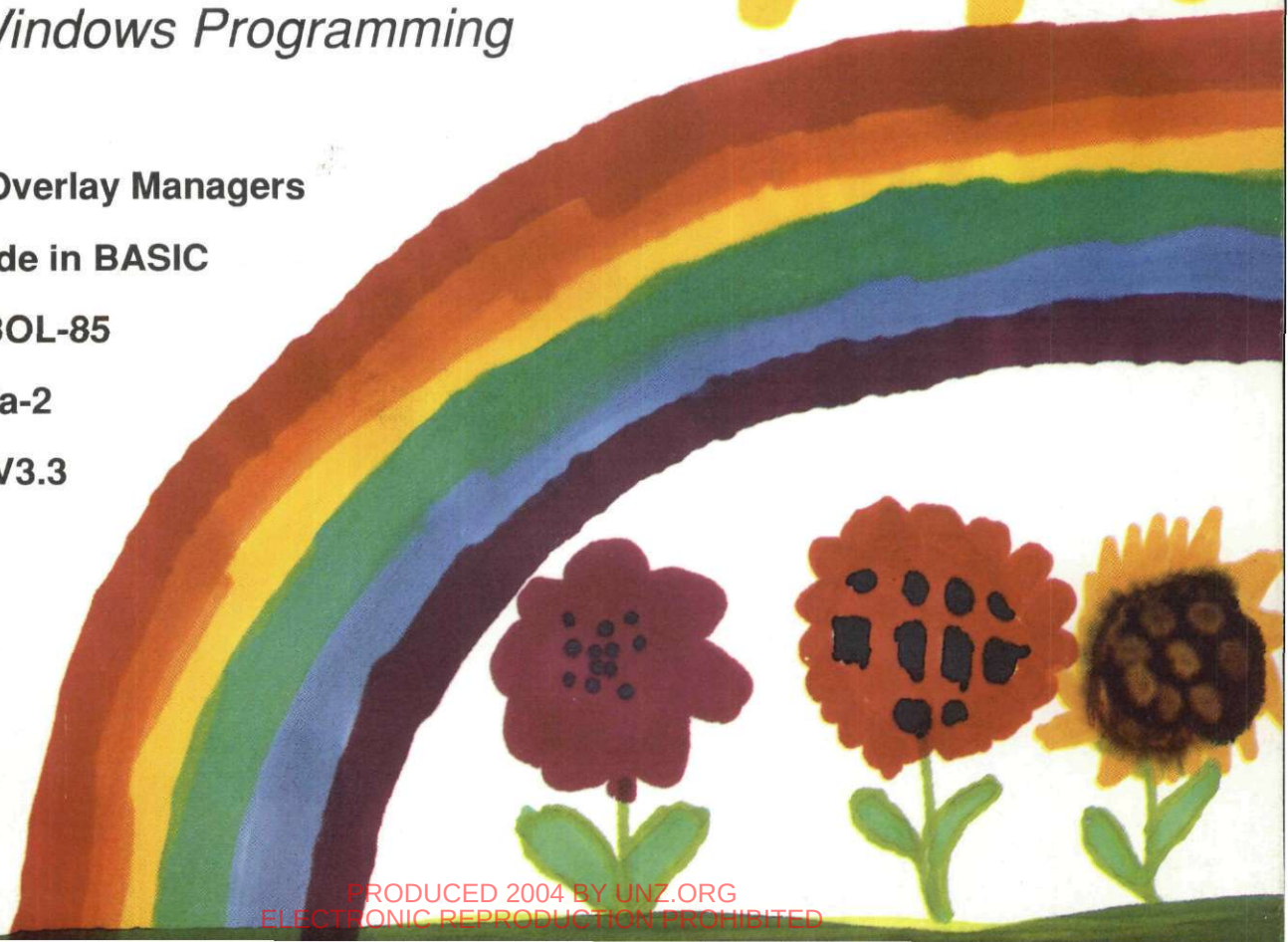
PASCAL Overlay Managers

Faster Code in BASIC

ANSI COBOL-85

JPI Modula-2

Lattice C V3.3



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MS-DOS $99

We call PolyAWK our "most flexible language" because it's a general purpose language that can replace a host of specialized tools or programs. You will still use your standard language (C, Pascal, Assembler, or other) or other modular language to develop applications, but you will write your own specialized development tools and programs with this versatile, simple and powerful language. Like thousands of others, you will soon find PolyAWK to be an indispensable part of your MS-DOS toolbox. If you don't have enough OS/2 development tools, now it's easy to write your own.

A True Implementation Under MS-DOS & OS/2

Bell Labs brought the world UNIX and C, and now professional programmers are discovering AWK. AWK was originally developed for UNIX by Alfred Aho, Richard Weinberger & Brian Kernighan of Bell Labs. Now PolyAWK gives MS-DOS & OS/2 programmers a true implementation of the valuable new programming tool. PolyAWK fully conforms to the AWK standard as defined by the original authors in their book, *The AWK Programming Language*.

A Pattern Matching Language

PolyAWK is a powerful pattern matching language for writing short programs to handle common text manipulation and data conversion tasks. A PolyAWK program consists of a sequence of patterns and actions that tell what to look for in the input data and what to do when it is found. PolyAWK searches a set of files for lines matched by any of the patterns. When a matching line is found, the corresponding action is performed. A pattern can select lines by boolean combinations of regular expressions and comparison operations on strings, numbers, fields, variables, and array elements; patterns may reference properties of the current input line or other program variables. Actions can perform arbitrary processing on selected lines. The action language looks like C, but there are no declarations and strings and numbers are built-in data types. You can have multiple input files and output files, regular expressions, user-defined functions, and nine other programs.

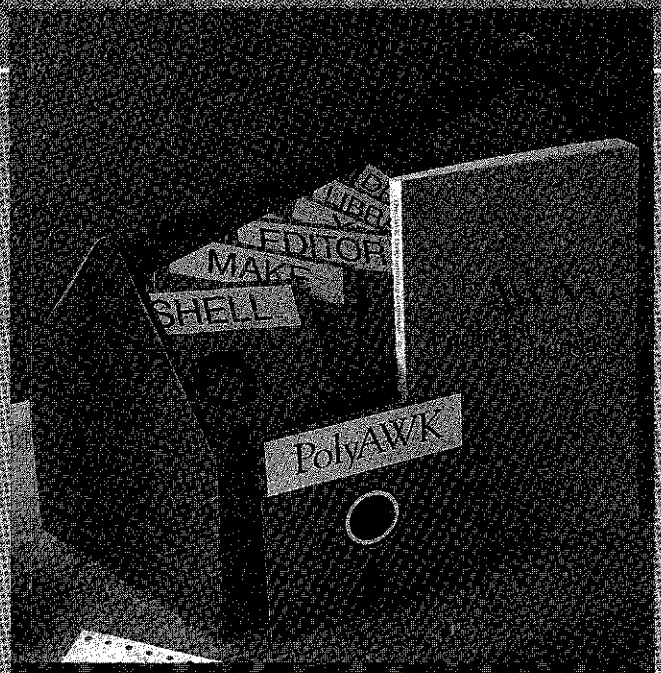
Saves You Time & Effort

The most compelling reason to use PolyAWK is that you can usually accomplish in a few lines of code what may take pages in C, Pascal or Assembler. Programmers spend a lot of time writing code to perform simple, mechanical data manipulation -- changing the format of data, checking its validity, finding items with some property, adding up numbers and printing reports. It is time consuming to have to write a special-purpose program in a standard language like C or Pascal each time such a task comes up. With PolyAWK, you can handle such tasks with very short programs, often only one or two lines long. The brevity of expression and convenience of operations make PolyAWK valuable for prototyping even large-sized programs.

Very Concise Code

Where program development time is more important than run time, AWK is hard to beat. These AWK characteristics let you write short and concise programs:

- The implicit input loop and the pattern-action paradigm simplify and often entirely eliminate control flow.
- Field splitting parses the most common forms of input, while numbers and strings and the coercions between them handle the most common data types.
- Associative arrays use ordinary strings as the index in the array and offer an easy way to implement a single-key database.
- Regular expressions are a uniform notation for describing patterns of text.



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- Because the interpreter and the absence of limitations shown in programs.

Large Model & Math Support

PolyAWK is a large model implementation and can use all available memory to run big programs or read files greater than 64K. PolyAWK also includes extensive support for math functions such as strings, integers, floating point numbers and transcendental functions (sin, log, etc.) for scientific applications. Conversion between these types is automatic and always optimized for speed without compromising accuracy.

PolyAWK Comes With The Book

When you order PolyAWK you receive a copy of *The AWK Programming Language* written by the authors of the original UNIX-based AWK. The book begins with a tutorial that shows how easy AWK is to use, followed by a comprehensive manual. Because PolyAWK is a complete implementation of AWK as defined by the book's authors, you will use this book as the manual for PolyAWK.

PolyShell Bonus For MS-DOS!

PolyShell gives you 70 of the most useful UNIX commands and utilities under MS-DOS in less than 20K. You can still use MS-DOS commands or any time and even restart PolyShell without rebooting. MS-DOS implementations of what you have been missing if UNIX programmers -- switch to MS-DOS names for PolyShell and PolyAWK, and use $39 when ordered separately. Save $50 by ordering the PolyShell + PolyAWK combination package for $89 (MS-DOS only).

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You can purchase PolyAWK and the book, *The AWK Programming Language*, for $99 (MS-DOS) or $199 (OS/2), or $249 for both if you already have the book. Add $14 for combination package includes only one book. Order PolyAWK (MS-DOS & OS/2) plus PolyShell (MS-DOS) for $134.

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Gordon Eubanks, Symantec — Q&A (386).

"It simply works, with no trouble, no chasing strange bugs, and excellent warning and error messages ... a professional product."
Robert Lerche, Bay Partners.

"For large-scale software development, the highest quality C compiler available on the market today. Pragmas are great. Quality of support is exceptional." **Randy Neilsen, Ansa—Paradox** (DOS,OS/2).

"15% smaller and 15% faster than Lattice C."
Robert Wenig, Autodesk.

"Our software is running anywhere from 30 to 50% faster than when compiled under Lattice." **David Marcus, Micronetics.**

"We switched from Lattice due to a 10% reduction in code size. The compiler is very stable." **Lee Lorenzen, Ventura Software — Ventura Publisher, marketted by Xerox Corp.**

"Best quality emitted code by any compiler I've encountered. Often amazing." **Bill Ferguson, Fox Software — FoxBase (386).**

"Messages sometimes pointed out type mismatches, incorrect-length argument lists, and uninitialized variables that had been undetected for years [in 4.x bsd]." **Larry Breed, IBM ACIS [RT PC].**

"Diagnostics turned up bugs missed by other compilers. Rapid bug fixes by technical support, someone who knew what he was talking about. 80386 code is well optimized."
Tim Addison, Logistics Data Systems.

"386 protected mode support is fantastic, especially the access to large amounts of memory. It's mainframe compute power on a PC." **Dan Eggleston, Viewlogic.**

"The preprocessor supplied with Professional Pascal is quite useful. The code quality and control over segmentation and memory models are superior to MS Pascal." **Bob Wallace, QuickSoft.**

Check Out These Reviews

- **High C ™:**

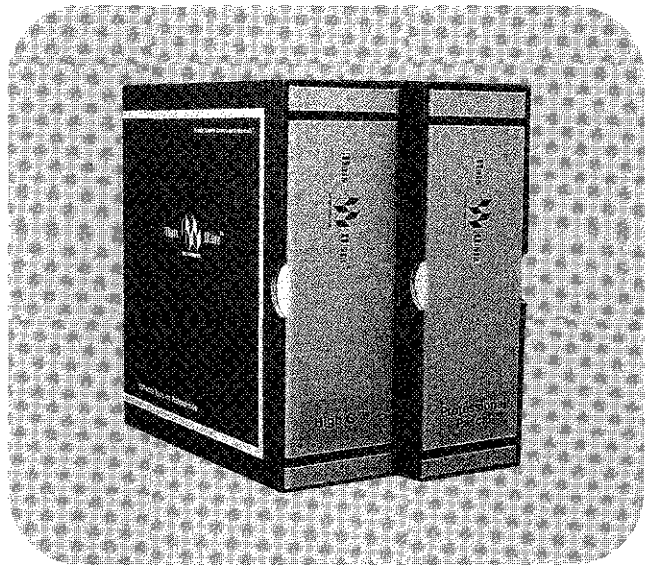
Computer Language	February 1986, '87	
Dr. Dobb's Journal	August 1986	
PC Magazine	Jan. 27, 1987	(80386 version)
Dr. Dobb's Journal	July 1987	(80386 version)
BYTE Magazine	November 1987	(80386 version)

- **Professional Pascal ™:**

PC Magazine	Dec. 29, 1985	
Computer Language	May 1986	
PC Tech Journal	July 1986	
Journal of Pascal, Ada, & Modula-2	Nov.-Dec. 1986	
BYTE Magazine	Dec. '86, June '87	(80386 version)

Why MetaWare compilers

- They are specifically designed for serious software developers.
- They are reliable and robust: they don't break at every turn.
- Their generated code is the best, or near best, on each architecture.
- Their superior diagnostic messages help you produce better products more quickly.
- Your source can be ported with ease to the most popular systems.
- You can link mixed-language modules from our compilers, others
- You can benefit from high-level, personal technical support.
- You can take advantage of the latest ANSI C extensions, and/or extensive Pascal extensions. **High C** has been tracking the ANSI Standard for two years; **Professional Pascal** will soon have a VS Pascal compatibility switch and several Apollo Pascal ext'ns.
- You can take advantage of the latest 387 and Weitek 1167 support — we have the only compilers with Weitek real mode support.



Power Tools for Power Users

Ashton-Tate: dBase III Plus, MultiMate; Autodesk: AUTOCAD, AUTOSKETCH (8087, '387, Weitek); Boeing Computer Services (Sun); CASE Technology (Sun); CAD/CAM giant Daisy ('86, '386, VAX); Deloitte Haskins & Sells; Digital Research: FlexOS; GE; IBM: 4.3/RT, 4680 OS; Lifetree Software (Pascal): Volkswriter Deluxe, GEM-Write; Lugaru: Epsilon; NYU: Ada-Ed cmplr; Semantec: Q&A; Sky Computers; ... (Product names are trademarks of the companies indicated.)

Industrial-Strength

MetaWare C and Pascal compilers are designed for professional software developers. These tools are loaded with options to control them for special purposes. You can adjust the space-time trade-off in code quality. You can adjust external naming conventions to agree with linkers and operating systems. You can specify segment names for segmented architectures, and to help place code or data in particular places for embedded applications. You can select from five memory models for the 8086 family. And on and on.

A Partial List of Optimizations

Common subexpression and dead-code elimination, retention and reuse of register contents, jump-instruction size minimization, tail merging (cross jumping), constant folding, short-circuit evaluation of Boolean expressions, strength reductions, fast procedure calls, automatic mapping of variables to registers (where advantageous), ...

"Platform" — Code Quality

Sun,Apollo,SGI	— 18%, 3%, 26% > resident compiler (Dhrystone).
PC: DOS, OS/2	— 3-10% > Microsoft C; 30% > MS Pascal, LatticeC.
386 32-bit DOS	— no competitors, since November, 1986.
286, 386 UNIX	— 66% better than pcc (Dhrystone, 386).
VAX VMS	— ≈ DEC's excellent C and Pascal; better features.
VAX Ultrix	— 19% > pcc (Dhrystone); much > Berkeley Pascal.
RT PC/4.3bsd	— 89% > the original port of pcc (Dhrystone).
370 CMS,UNIX	— much better than any C, and VS Pascal.
AMD 29000	— >40,000 Dhrystones! Available in Q2, cross.

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The Resource Journal for IBM Micro Programmers

PROGRAMMER'S Journal

Volume 7.1
January/February 1989

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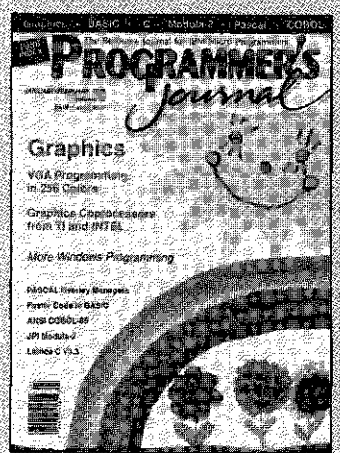

Our preoccupation with color and graphics begins at an early age. The two hundred fifty-six colors of the VGA can bring out the child in anyone.
Cover Artist: Deirdre Bentley, age 6
Art Director: Ralph Bentley

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Break out of hung programs
With a keystroke - no external switch necessary. Even with interrupts disabled.

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Soft-ICE uses ZERO bytes of memory in the first 1MB of address space. This is especially useful for those subtle bugs that change when the starting address of your code changes. With Soft-ICE your code executes at the same address whether the debugger is loaded or not.

Works with your favorite debugger
Soft-ICE can be used as a stand-alone debugger or it can add its powerful break points to the software debugger you already use. You can continue to use your favorite debugger until you require Soft-ICE. Simply pop up the Soft-ICE window to set powerful real-time break points. When a break point is reached, your debugger will be activated.

Solve tough systems problems too
Soft-ICE is ideal for debugging TSRs, interrupt handlers, self booting programs, DOS loadable device drivers, non-DOS operating systems, and debugging within DOS & BIOS. Soft-ICE is also great for firmware development because Soft-ICE's break points work in ROM.

How Soft-ICE Works
Soft-ICE uses the power of the 80386 to surround your program in a virtual machine. This gives you complete control of the DOS environment, while Soft-ICE runs safely in protected mode. Soft-ICE uses 80386 protected mode features, such as paging, I/O privilege level, and break point registers, to provide real-time hardware-level break points.

"Soft-ICE is a product any MS-DOS developer serious enough to own a 386 machine should have."
Dr. Dobb's Journal — May 1988

RUN CODEVIEW IN ONLY 8K!

CodeView is a great integrated debugger, but it uses over 200K of conventional memory. MagicCV uses advanced features of the 80386 microprocessor to load CodeView and symbols in extended memory. This allows MagicCV to run CodeView using less than 8K of conventional memory on your 80386 PC.

Don't let 640K be your limit!
If you are closing in on the 640K limit and would like the power of CodeView, MagicCV is for you.

Don't let the debugger hide the bug!
Even if you're not closing in on the 640K limit, running CodeView with MagicCV makes your debugging environment much closer to the end user's program environment. You can use CodeView to locate subtle bugs that only occur when there is plenty of free memory, or those difficult bugs that only occur when your program is running with a couple of TSRs loaded.

How MagicCV works
MagicCV uses the 80386 to create a separate virtual machine for CodeView. MagicCV uses between 4K & 8K of conventional memory as a bridge between the DOS environment and CodeView.

MagicCV is easy to use
If you are a CodeView user, you already know how to use MagicCV too. Just type MCV instead of CV; everything else is automatic.

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MagicCV with Soft-ICE
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Both require 80386 AT compatible or IBM PS/2 Model 80. MagicCV requires at least 384K of extended memory. CodeView is a trademark of Microsoft Corporation.

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The Resource Journal For IBM PC Programmers
PROGRAMMER'S Journal

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Here I sit, the week before Comdex, befuddled by the PC marketplace. I'd rather compose these lines after the show, but the vagaries of magazine schedules intervene. Fall Comdex in Las Vegas has to be experienced for its full impact. The magnitude of the PC industry is rather overwhelming when successful companies can drop $250,000 to $500,000 for a booth at the week-long show. Sure, deals are cut for the coming year; but the importance of publicity and marketing are what Comdex so clearly demonstrates. Be it software or hardware, the best product is unlikely to make it without an enterprising and often costly "dog and pony show."

OS/2 While Technology Waits

Let's slip back eight years in time. In our time capsule we travel to the land of CP/M, those wonderful dual-CPU S-100 boxes from CompuPro, and the funny, little Z-80 portables with teeny screens from Adam Osborne . . . Many small hardware and software vendors without any beanstalk giant . . . Healthy doses of competition and technological advancement.

Enter IBM, from the mainframe world, with their IBM PC . . . Immense success, probably beyond their own expectations. IBM offers standardization, not technological leadership. The marketplace becomes dominated by copies and clones rather than technological advances. But technology can be held back only so long. Now let's return to the present.

IBM and Microsoft have clearly stumbled with OS/2, Presentation Manager, and various extended editions. What at once seemed a "shoo-in," a "piece of cake" for the next operating system and graphics standard, every week slips farther away from reality. If . . . if . . . if DOS 5.0, ADOS, what's now called OS/2, had been delivered two years ago, maybe things would be different now. I attended Comdex last year to see the promised OS/2 software and PS/2 hardware. A year later, not much of substance has materialized. Maybe I'll return next week pleasantly surprised, but I'm not practicing hold my breath. Who knows, maybe I should be studying snorkeling?

Yes, decent OS/2 software development tools are gradually becoming available, but most products are straight ports from the DOS world. User applications are a different story, since they must offer enhanced features such as graphics, sophisticated user interfaces, and greater performance to compete with existing DOS products. That's a big part of the wrinkle. In the past, we complained about PC Unix, since it required 500K for the operating system. Don't ask how much the latest edition of OS/2 with PM takes. Feedback from early business testers is not encouraging. Some suggest 386 machines with 4–8 megabytes of memory as a base configuration for OS/2. While OS/2 slowly evolves into a real product, the 80386 is being stuffed into more and more machines.

But OS/2 doesn't take advantage of any of this 80386 power. The 386 DOS extenders—which by all accounts should never have existed—are alive and well, with new products arriving steadily. Applications based on the 286 DOS extenders from Rational Systems and A.I. Architects are settling into the marketplace. 386 Unix implementations run DOS programs as just another task. With ever-higher-resolution graphics hardware, the likes of X-Window and Display Postscript moving down to the PC are clearly threatening the long-term market for Presentation Manager and its precursor, Windows.

Although IBM and Microsoft have officially met their deadline for delivering Presentation Manager (at least in the press), most developers with OS/2 Software Development Kits are still awaiting the arrival of this latest PM release. I'll wait until the OS/2 developers have a crack at this first "stable" release of PM before holding judgment. Does it really require 400 new system calls for a graphical interface? What ever happened to Sparta?

PJ Staff Changes

A few changes at *PJ*. Bob Wanetick, fresh from editing several popular computer books, has joined our staff as Managing Editor. We welcome him to the growing *PJ* family.

Erin O'Connor, our stalwart editor, has departed for greener pastures. I'm sorry to see her go. She was exceptional—a talented, hardworking, and meticulous journalist who insisted on the highest standards for *PJ*. We wish her well. In her stead, we have a lowly programmer—perish the thought. —*Steve*

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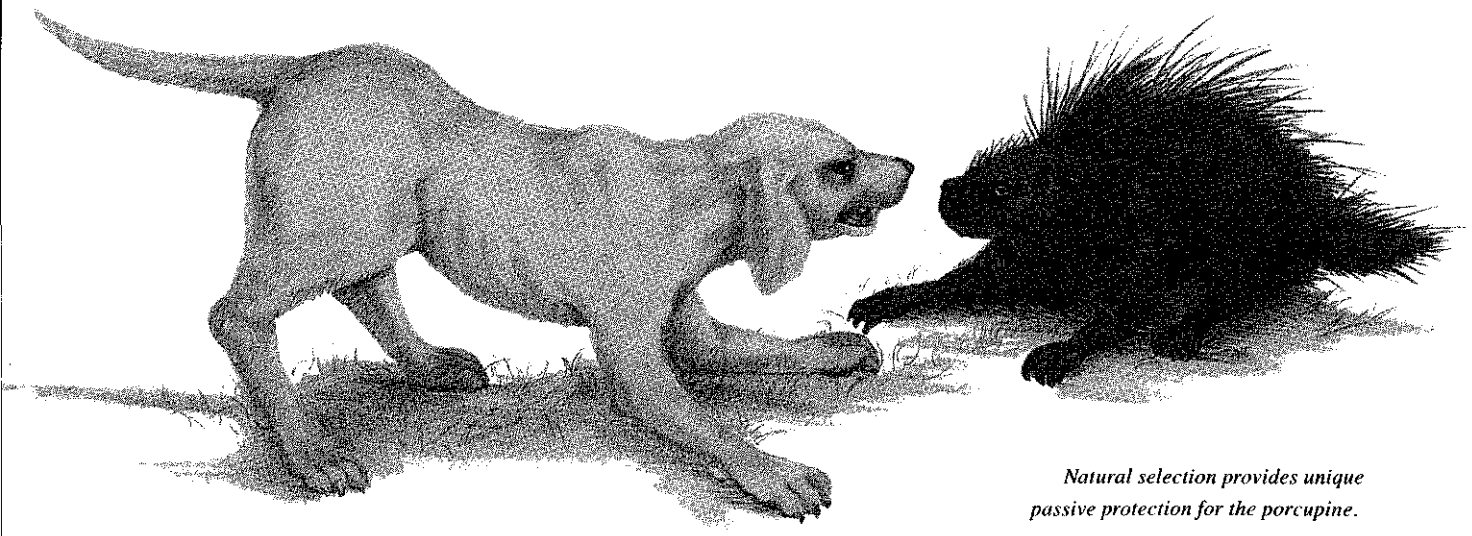

Natural selection provides unique passive protection for the porcupine.

The Activator - Natural Selection For Software Protection

Inventor and entrepreneur Dick Erett explains how "The Activator" provides sane protection for your intellectual property.

"In any industry, just as in nature, the process of natural selection raises one solution above another. Natural selection is the most elegant of engineers.

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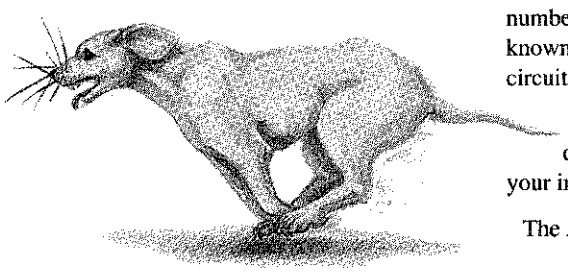

By removing protection from the magnetic media we remove the constraints that have plagued legitimate users.

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Full 100% Disclosure

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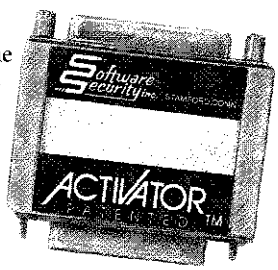

Just as no two snowflakes are the same, no two implementations of The Activator are identical. And like the snowflake the simplicity of The Activator is its greatest beauty.

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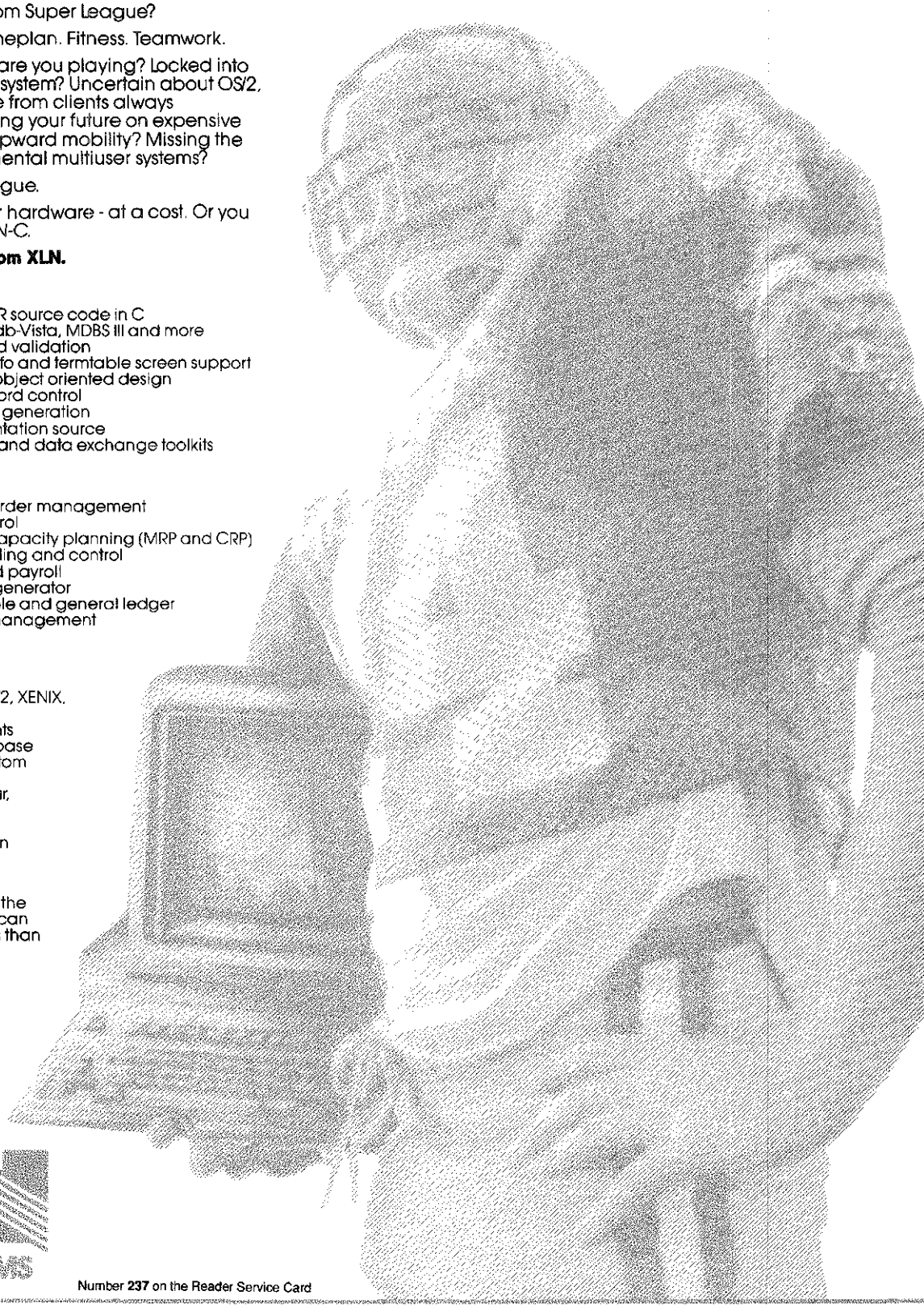

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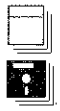

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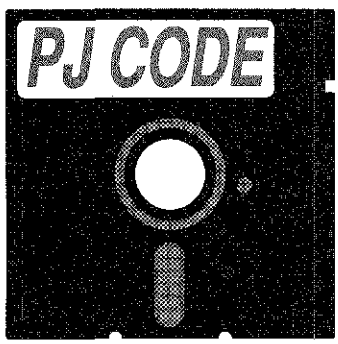

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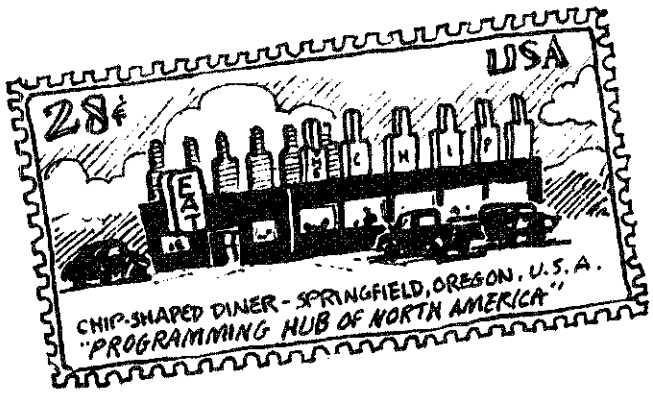

Here We Go Again
(And It's About Time)

I was delighted to see Terry Ritter's response to my note about structured programming (*PJ* 6.5). Here is clearly someone who refuses to swallow the whole cow regardless of how appetizingly it's presented!

Mr. Ritter is in good company. Several years ago, one of the computing luminaries (Don Knuth, I think) published an article entitled "Structured Programming with GoTo's." At about the same time, someone else (I forget who) published an article entitled "Structured Programming—Good Heuristics, or Bad Dogma?"

The titles say it all. There is nothing inherent in the GoTo that *forbids* construction of clear, understandable, maintainable code. Nor is there anything magical about structured programming that *guarantees* that the resulting code will be of stellar quality.

This misses the real point of Dijkstra's letter, however. Dijkstra's real contention was that the presence and undisciplined use to the GoTo precluded any algorithmic proof of correctness. The fact that non-use of the GoTo generally (but not always, as correctly pointed out by Mr. Ritter) results in more readable code is serendipity. Nothing more.

Regarding Mr. Ritter's comments that a computer program is a form of literature, one cannot reasonably disagree. But the concept needs to be carried even further, into the realm of program documentation.

My view here completely agrees with that of Dijkstra:

"Eventually, there are two 'machines.' On the one hand there is the physical machine that is installed in the computer room. . . . On the other hand there is the abstract machine as defined in the manual, the 'thinkable' machine for which the programmer programs and with respect to which the question of program correctness is settled.

"Originally I viewed it as the function of the abstract machine to provide a truthful picture of the physical reality. Later, however, I learned to consider the abstract machine as the 'true' one, because that is the only one we can 'think'; it is the physical machine's purpose to supply a (hopefully) sufficiently accurate physical simulation of the true, abstract machine." (Dijkstra, E.W., *A Discipline of Programming*, Addison-Wesley, 1976, p. 201.)

Replace the word *machine* with *program* and *programmer* with *user*, and make a few other necessary editorial changes. Now try to justify changing the documentation to make it fit the program instead of vice versa.

W.G. Madison
Greenbelt, MD

Apologies to Swan

Please allow me to apologize to Tom Swan and the *PJ* readers for any confusion that I may have caused with my letter in *PJ* 6.4. When I read "A Case of the Jumps," I thought that Mr. Swan was simply trying to find another way to code a Case statement. I felt that my suggestion would run faster than the TP4 cascaded CMP, JMP statements. What I meant by "more efficient" was better use of memory; I was aware that Mr. Swan's code would run faster. Since I learned to program in the CPM days, I balked at the wasted memory.

Michael Frame's "compromise code" is a very good idea. It allows fast execution time and memory savings. For what it's worth, here is the assembly code:

```
CODETABLE DB     49 DUP(0),1,2
          DB     37 DUP(0),3,40 DUP(0)
JTABLE    DW     ENDC,CASE1,CASE2,CASEX
          MOV    BX,OFFSET CODETABLE
          AND    AX,7FH
          XLAT
          SHL    AX,1
          MOV    BX,AX
          JMP    JTABLE[BX]
          ...
          ...
CASE1:
CASE2:
CASEX:
ENDC:
```

In this example, valid selectors are 1, 2, and X.

Adrian B. Crum
La Habra, CA

OS/2 Presentation Manager Changes

Since my article "An OS/2 Presentation Manager Application Template" appeared in *PJ* 6.5 (September/October 1988), Microsoft has altered the API enough to break the original code. In particular, WinCreateStdWindow has changed. I am including a new version, which should compile and run correctly under the current PM SDK, version 4.99. I hope you can make the new code available on the *PJ* Bulletin Board.

Bill Hall
La Habra, CA

[Thanks, Bill, for keeping us current.—Ed.]

The Weiner Shell Language

In "The REXX Language on the PC" (September/October 1988, Volume 6.5), Andrew Chalk points out that although REXX does extend the DOS batch language somewhat, it has many limitations. Some of those limitations are 384K of memory overhead, minimal DOS-specific features, and no interrupt capability. I'd like to let your readers know about a product that addresses all these limitations. The Weiner Shell language from GRYPHON Microproducts adds about 140 commands to DOS and to any other software being run. Its features include array-processing, floating-point math, pop-up scrollable windows, light-bar menus, user I/O control, table look-ups, background telecommunications, DOS interrupts, and database (dBASE) file access. The language is extendable, which means that users can define their own functions, even those written in other languages, and add them to the Shell. The Shell engine is memory-resident. It requires as little as 45K and can take advantage of LIM-spec memory. It may be removed from memory without rebooting the system. Business-Graphics and Statistics add-ons are also available.

The Shell is a high-level language, similar to a cross between dBASE and Assembler. All commands are executed by "pushing" parameters onto a stack and then executing the stack. Each parameter is surrounded by a delimiter. The default delimiter is the char ~ and may be changed by the programmer. Each command line begins with a command verb and is followed by its parameter list. For example, to print the string "Hi y'all world" to the screen, the following syntactical elements would be used:

```
~atsay~ ;This is the verb
~Hi y'all world~ ;this is the first
    (only) parameter
~~ ;a null parameter says "run the stack"
```


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Placing this all together, the command line would read:

```
~atsay~~Hi y'all world~~~
```

In Shell terminology, this is called a delimited string. The actual line from a DOS batch file would be

```
NULL ~atsay~~Hi y'all world~~~
```

The Weiner Shell also has a more natural (squiggle-less) syntax for DOS.

Results of an operation are communicated to the calling program in several programmer-defined ways: through the DOS environment, through the ICA, through the keyboard buffer, through Shell system variables, through arrays, through the serial port, through the printer port, or through use of files. In addition to being able to call all 140 commands directly from DOS, you can call commands from other applications and languages. There are seven different ways to call programs written in the Shell language: (1) direct memory calls to the Shell interrupt (usually 7Fh); (2) timed events; (3) screen events; (4) activated by hot-keys; (5) started when specified background communications events occur; (6) activated by printing delimited strings to the Printer; and (7) activated by printing delimited strings to the NUL device.

All the Shell commands are based on arrays. Arrays may be created and erased dynamically. They can be saved to and restored from disk, in both compressed and ASCII-text form. Normally, an array contains data, but in the Shell language, an array may also contain screen snapshots and programs. Programs can be sequences of Shell commands (command arrays) or user defined functions (UDFs) written in other languages. About 120 of the Shell commands are actually UDFs. Any of those UDF arrays may be erased to lower the memory requirements of the system. Arrays created in one environment (in LOTUS, for example) are maintained after that application terminates. Arrays may therefore be used as a pipeline to cut and paste data between applications.

Additional information is available on our bulletin-board at (301) 384-7238.

Alan Weiner
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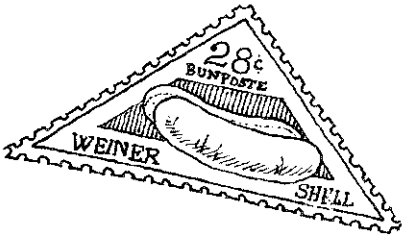

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—Robert Hummel, Senior Technical Editor, PC Magazine

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```
resetprn.lst    ResetPRN v1.01              Sourcer Listing    19-Apr-88  4:05 pm     Page 1

                                PAGE  60,132
                                ;-----------------------------------------------------------------------
                                ;                              RESETPRN
                                ;
                                ;       Created:   15-Apr-88
                                ;       Version:   1.01
                                ;-----------------------------------------------------------------------

= 0008                          data_1e         equ     8               ; (0040:0008=378h)

                                ;---------------------------------------------------------- seg_a -----
                                seg_a           segment para public
                                                assume cs:seg_a, ds:seg_a, ss:stack_seg_b

                                resetprn        proc    far
658E:0000                       start:
658E:0000  EB 23                                jmp     short loc_1
658E:0002  52 65 73 65 74 50                    db      'ResetPRN v1.01', 0Dh
658E:0008  52 4E 20 76 31 2E
658E:000E  30 31 0D
658E:0011  0040                 data_2          dw      40h
658E:0013  0D 0A 52 65 73 65    data_3          db      0Dh, 0Ah, 'Reset Printer? $'
658E:0019  74 20 50 72 69 6E
658E:001F  74 65 72 3F 20 24
658E:0025                       loc_1:
658E:0025  0E                                   push    cs
658E:0026  1F                                   pop     ds
658E:0027  BA 0013                              mov     dx,offset data_3  ; (658E:0013=0Dh)
658E:002A  B4 09                                mov     ah,9
658E:002C  CD 21                                int     21h               ; DOS Services  ah=function 09h
                                                                          ;  display char string at ds:dx
658E:002E  B4 01                                mov     ah,1
658E:0030  CD 21                                int     21h               ; DOS Services  ah=function 01h
                                                                          ;  get keybd char al, with echo
658E:0032  3C 79                                cmp     al,79h            ; 'y'
658E:0034  75 16                                jne     loc_3             ; Jump if not equal
658E:0036  8E 1E 0011                           mov     ds,data_2         ; (658E:0011=40h)
658E:003A  8B 16 0008                           mov     dx,ds:data_1e     ; (0040:0008=378h)
658E:003E  83 C2 02                             add     dx,2
658E:0041  B0 08                                mov     al,8
658E:0043  EE                                   out     dx,al             ; port 37Ah, printer-2 control
                                                                          ;  al = 8, initialize printer
658E:0044  B9 8000                              mov     cx,8000h
658E:0047                       locloop_2:
658E:0047  E2 FE                                loop    locloop_2         ; Loop if cx > 0
658E:0049  B0 0C                                mov     al,0Ch
658E:004B  EE                                   out     dx,al             ; port 37Ah, printer-2 control
                                                                          ;  al = 0Ch, init & strobe off
658E:004C                       loc_3:
658E:004C  B4 4C                                mov     ah,4Ch            ; 'L'
658E:004E  CD 21                                int     21h               ; DOS Services  ah=function 4Ch
                                                                          ;  terminate with al=return code
                                resetprn        endp
                                seg_a           ends

                                ;---------------------------------------------------------- stack_seg_b ----
                                stack_seg_b     segment para stack
6593:0000  00C0[FF]                             db      192 dup (0FFh)
                                stack_seg_b     ends

                                                end     start
```

(Source code output and inline cross reference can also be selected)

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Pink Noise

by
Frank D. Greco

X.12?
One of the X Window System's several technical drawbacks is that it's a very resolution-dependent (i.e., pixel-based) window system. Sun Microsystems' elegant NeWS window system, based on PostScript, is totally independent of screen resolution. The scuttlebutt among certain people at the last Usenix convention: A good bet that the next generation X Window System, X.12, will be very similar to NeWS today. Although technically inferior to NeWS, the X Window System probably will be very popular in the near-term future (two to four years). In the long run, however, the sheer elegance of NeWS will win out—*if* Sun applies some *significant* effort toward fixing the bugs and enhancing the package. If Sun—or some third party—does not produce some significant software product using NeWS, then we can expect X Window to survive, leaving NeWS to be a technically interesting but commercially unsuccessful product. I certainly hope that we don't have a repeat of the Sony Betamax versus VHS battle. (If you recall, Sony's Betamax VCR technology was technically superior, but the industry-standard VHS proved victorious.)

Rooms for Rent?
A recent issue of PC Week had Xerox-spinoff Envos talking to Microsoft about Envos's "Rooms" graphical metaphor. I wonder if Microsoft knows about the licensing arrangement between Xerox and Sun regarding user interface technology?

Ring Ring at Sing Sing
Did you know that prisons are a major source of income for AT&T? It seems that prisoners call their relatives and friends and remain on the phone all day long.

I Object
The originator of the Ingres database, Dr. Michael Stonebraker, has been busy at work implementing his newest invention, Postgres. Postgres is an object-oriented layer around a conventional relational database. While there is some benefit to basing Postgres on the relational model—backward compatibility with a query language for one thing—I really feel that we must take a step backward and build object-oriented databases from scratch. It just does not "feel" right to build an object-oriented database out of a relational one; it's really a kludge. In my opinion, the number of relations required to formulate an arbitrarily complex, object-based query will increase so much as to significantly degrade performance. Anyway, rumor has it that Stonebraker's boys at Berkeley are also attempting to put Postgres on a chip.

Someone in a California university has been busy at work reverse-engineering the Adobe font metrics (the so-called "proprietary hints"). Within six months, PostScript clones will all be able to license this work.

With the acquisition of Folio, Sun Microsystems is actively incorporating Folio's sophisticated font technology into NeWS. By doing so, the PostScript-based NeWS will be able to use non-Adobe fonts in any point size. Folio's software also handles generating the so-called "hints" to render fonts aesthetic (and readable) at small point sizes.

A RISC for Apple
Very strong evidence exists for RISC development going on at Apple. Two former members of defunct Ridge Computers (which used RISC technology)—one a founder, the other an R&D executive—have joined the Apple Corps.

Lord of the Rings
Supercomputer vendor Scientific Computer Systems is now offering the fastest (1.4 gigabytes per second) token ring local area network. Vectornet, as its called, also has the ability to gateway to other LANs.

Japan Inc.
Toshiba and NEC have both announced their working prototypes of charge-coupled device (CCD) image sensors in the 1035x1920 pixel resolution. The chip is 16.5 by 10 millimeters and will be available in commercial products within two years.

Sharp recently announced the availability of a 14-inch color LCD unit.

The recent Matsushita/Sun deal looks to be the start of some significant dealings with the Japanese. Apparently, Matsushita will build parallel-processing Sun-compatible workstations. According to my Japanese contact, the SPARC microprocessor is "very" attractive to the ever-growing Japanese computing industry. (The Tokyo University–created TRON architecture is starting to lose favor in Japan). I expect Fujitsu will soon follow suit with a low-end SPARC-based workstation. Don't expect it to stop there: Bill Joy has been spending a *lot* of time in Japan. I can think of several other companies in Japan that could make very profitable use of Sun's SPARC.

Don't forget that SPARC is *not* a chip; it is an architecture. Sun does not make a SPARC chip. Other companies license the architecture and fabricate hardware from the specifications.

A book publisher from Japan told me recently that the Japanese have an insatiable appetite for American software books. The most popular books in recent weeks have been K&R's C classic and texts on PostScript.

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Does Sun Really Need AT&T?
A very prosperous workstation company like Sun does not need AT&T for the money. All the trade press are saying that Sun is going to use the "much-needed" cash infusion for R&D. What much-needed capital? Sun does not need AT&T's money. Just like the real reason that Sun wanted to consolidate their variety of Berkeley-tinged Unix (a really good one, I might add) and AT&T System V is for lucrative government bids. We're talkin' Big Bucks. Perhaps Sun wants access to AT&T's vast telecommunication customer base (PBXs, Large Central Office switches, wide area networking, and so on). Sun knows that the telecomm market is growing like hotcakes. With this information, Sun can now have the muscle to go against IBM and DEC. There is only one caveat: AT&T must leave Sun alone.

It really looks like Sun is taking over Wall Street. Many MS-DOS 386 machines are being replaced with Unix-powered Sun workstations; the Sun-4 seems especially attractive to many in the financial community. And it seems that the new 386i machine is also selling like hotcakes. Many of my clients have asked about its capabilities. Running DOS windows alongside Unix windows really comes in handy. It's really cute when you can open a named pipe on the 386i's Unix side, have a DOS process write to the pipe, and then have a Unix process read from the other end of the pipe.

Once the Windows driver is written for the Sun 386i, it could be a *very* attractive Windows development machine. After all, you need a serial terminal connected to your machine to debug MS Windows. With the 386i, you already have virtual terminals in SunView windows. So the serial "terminal" could be a second DOS window right next to your MS Windows window!

Build Memory Power
Many people misread Sun's recently-announced strategic agreement with Texas Instruments. All the trade rags pointed out how TI was going to use the SPARC processor in all their workstations. Who really cares about TI's workstations? Sun scored another coup by signing a *major* U.S. DRAM manufacturer on its team. Sun will obviously get preferential treatment when it comes to that scarce commodity called DRAMs. Not to mention TI's SPARC-compatible floating point chip and low-cost 34020 graphics processor.

A strong rumor has Sun merging their PC-NFS and TOPS networking software products. Many Macintosh owners would like the network transparency of NFS, but NFS does not (officially) exist for the Mac. TOPS is the only SUN network product available, although the two products overlap somewhat in the marketplace. Even though TOPS runs on AppleTalk and NFS runs over TCP/IP, it seems natural that these very successful products will eventually merge.

A Fujitsu representative told me recently that they have 40-MIPS versions of the SPARC architecture on the shelf ready to go (and Sun has samples in their labs). The reason for the delay (according to this techie): The agreement with Sun constricts Fujitsu from announcing new SPARCs "too early." Apparently, Sun feels that sales of their first-generation Sun-4 line (based on the Fujitsu MB86900 SPARC) might be affected negatively if potential customers hear of an even faster SPARC.

There are rumors that Perceptics, the VMS imaging vendor, is working on a machine called the Parallax, which uses several Sun's Sparc RISC processors and reaches supercomputer performance.

Judging from what I have seen and heard, I think the SPARC architecture will be a *big* winner.

NeWS News
Dave LaVallee, one of Sun's gifted NeWS programmers, appears to be headed for Sun's Advanced Technology Group. Based on his comments during the last few NeWS seminars, it looks as if he's implementing a hypermedia system based on NeWS. It seems that another NeWS aficionado and premier NeWS programmer, Don Hopkins of the University of Maryland, is porting HyperTIES, a hypermedia system, over to the Postscript-based window system.

Pop-up in the "In" Field
The trend in user interfaces suggests that the next generation will incorporate animation as a significant constituent. Notice that the "better" pop-up menus and windows don't just instantly appear on the screen. If user's blink their eyes, they may miss a window event. Newer computer animation for your local TV weather person is a widespread example—slowing down the action via clever animation so that the viewer sees the temperatures slowly appearing (sliding, sparkling, fading in) on the screen. While the techie wants his pop-ups to *snap* onto the screen in a microsecond, the end user is much more pleased with some ingenious animation. And besides, the animation (if it's done correctly) forces the user to concentrate.

Imperfect WordPerfect
According to a few in the know, there are two versions of the oft-touted WordPerfect 5.0. The version with the 5/88 date has a few bugs; the 7/88 version is the one you want. If you have the 5/88 version, the "maintenance version" is relatively cheap and may even be free, depending on when you purchased 5.0.

What's NeXT?
Clues to next year's software for Steve Job's NeXT machine are found in the past work done by the programming staff at Lucasfilms. Most of the programmers from Lucasfilms' "Droid Works" division now work for Mr. Jobs. Some of their very interesting work includes combining animated images, sound effects, and music on Sun Microsystems workstations. I saw an amazing demonstration of a visually oriented sound editor at the Portland Usenix created by Mike Hawley, et al.

Rumors in the university circuit have it that Mr. Jobs is keenly interested in graphics pioneer Andries Van Dam's work with BALSA at Brown University.

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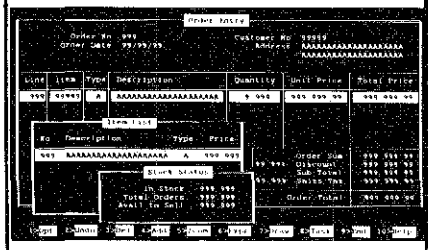

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It also seems that Jobs wants to do Apple's Hypercard one better by incorporating hypermedia elements into the NeXT workstation's user interface.

Similar to Sun's strategy, MIPS Computer Systems has decided to license the manufacturing of their processors. LSI Logic, Integrated Device Technology, Inc., and Performance Semiconductor Corp. are now licensed to manufacture the MIPS R2000 RISC-based processor. Performance Semiconductor has promised a 20-MIPS version of the R2000 by the end of 1988.

Da Vinci Systems Corporation of Raleigh, North Carolina, (near Research Triangle) has extended Microsoft's Dynamic Data Exchange (DDE) across networks. Their software product, called "Dispatcher," uses the NetBIOS protocol and will—it's still in development—cost less than $100. This will allow processes to send data dynamically to any other active process on a network. While new to the MS-DOS world, such interprocess communication has long been done in the Unix world using "sockets".

Expect to see very-high-density floppy disk drives available by early 1989. Brier Technology (408-435-8463) promises a 20-megabyte, 35-ms, 3.5-inch drive that will use new high density Barrite media 3.5-inch "floppy" disks. Irwin Magnetic Systems will OEM the technology in a commercial product during the first quarter. Brier's 40-megabyte version will be available sometime in mid 1989.

I noticed that the TI 34010 does not do arbitrary polygon clipping, only rectangular; so it may not be that applicable for a PostScript Raster Image Processor (RIP).

From Math Maestros to PostScript

I saw Weitek's newest Postscript hardware recently and was thoroughly impressed. This board renders Postscript images so fast that it must be slowed when communicating with the laser engine. I saw the board connected to an HP LaserJet—amazing! The board processed complex graphics and multifont text at the rated speed of the laser engine. And this is a first-generation product! Rumors have it that Weitek's hardware will be used by Adobe in the newest "Hercules" PostScript controller. The Weitek people have mentioned that they are developing a version that assists Display PostScript in rendering PostScript images on screen. I would bet money that these people are also talking to Sun regarding NeWS, since it too is PostScript based.

Very soon someone will be announcing a tabletop typesetter with resolution of up to 5040 dpi for just over $10,000. While the ordinary letter writer does not need this resolution, small print shops could compete (somewhat) with the big shops.

Lotus Pay Our Taxes

According to the *WSJ* dated 3/23/87, Jim Manzi, the president of Lotus Development Corporation, stated that he had to sell 250,000 shares of Lotus stock to cover his taxes. At the current rate of $28.75 per share, that's $7,187,500 just to cover his taxes!

Wholly Holography!

Hughes Research Lab has managed to store images in holographic format. Using optical associative memory, neural network software, and holography, these scientists are able to reconstruct a complete image from only 20% of the image's data.

AT&T has announced that Sun's Remote Procedure Call (RPC) and Network File System (NFS) will be included in System V Version 4. Also, some features from Berkeley Unix will be included (I pray that job control will be one). I'm waiting for the day that all Unixs have a standard RPC mechanism; this announcement just makes it a matter of time.

Thanks for the Memories

At the last International Solid State Circuits Conference, Toshiba, Hitachi, and Matsushita all discussed 16-megabit DRAMs. The companies seemed confident that production quantities would be available by 1990. Let's hope the Japanese/American DRAM situation will be resolved by then.

At the same conference, General Electric and Matsushita both described graphics processors that do hidden-line removal for 3-D applications. Toshiba described their new BITBLT chip, which does 40 megapixels per second. Just to give you an idea of the speed of this chip, it can redraw an entire 256-color 1024x1024 screen in .025 seconds.

A Waste Is a Terrible Thing to Mind

AT&T's Jack Scanlon, when asked why the price and performance of a RISC processor is better than that of a CISC processor: "An Intel 80386 chip today costs $300—even if I put all of New York

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City on the chip." OK, Jack (the doctor says to play along with him).

That's Logical
One of Sun's biggest OEM's, Toshiba, is going to put their IP704 AI microprocessor into every Sun workstation that they resell. Supposedly, this processor can run LISP, Prolog, or C and can perform at 600 KLIPS (Logic Inferences Per Second). Toshiba calls this Sun-based workstation the AS4000.

Call Ripley
Isn't it a really weird coincidence that when you reverse the name of the inventor of DEC's DECTALK voice synthesizer, MIT's Klatt, who has a speaking disability himself, you get ttalk! Weird.

Getting Wired
Edge Computers, of Scottsdale, Arizona, has implemented the architecture of the Motorola 680X0 using high-speed gate arrays, hardwired control logic, advanced pipelining, and nifty caching techniques. By doing this, Edge has greatly enhanced the performance of the microprocessor up to 16 MIPS. If you connect four of these processors together, you can get a sustained 55 MIPS. Edge is not a second source of the Motorola part; they are only producing a powerful computer engine that is instruction-set compatible with the 680x0. Apparently, the "Edge-ites" are also currently working on 80286 and 80386 versions.

Twisted Pair
DEC and Radio Shack????? I'm sorry, but I don't see the advantage that DEC derives from this marriage.

Did-You-Know Dept.
Interactive Systems, which is porting AIX for IBM (and DEC and HP and Apollo), is owned by Kodak.

Soda Pop Will Fizzle Out
Is the real reason that Apple's John Sculley is suing Microsoft and HP because he wants to license the Apple Macintosh interface to the PC world? Rumors abound of Mr. Sculley's indication to the Apple spin-off, Claris, that a Macintosh programmers' toolkit written and licensed for the PC world would be a big moneymaker for Apple. Whatever the real reason, I think that Apple's lawsuit will eventually come back to haunt the corporation.

continued . . .

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Optical Info

Verbatim, owned by Eastman Kodak, will soon announce an erasable 3.5-inch optical disk drive. Information that I received from a recent optical technology conference shows Verbatim about a year away from releasing this commercially. The drive will use a half-height format and thermo-magneto optical technology. Representatives told me to expect the first-generation product to have 50- to 100-megabyte capacity, 70-ms access times, and 1-megabyte-per-second transfer rates.

Apparently these optical devices will be used as floppy disk replacements, although their ability to replace winchester hard drives is up in the air. Hybrid vertical recording techniques appear to stretch the life of winchesters a little longer than previously expected. Representatives from such companies as IBM and new start-up Censtor are predicting 100-megabyte hard cards within a year and 1-gigabyte external drives within two years.

NEC's new PD72185 image compression/reconstruction chip for black-and-white images can perform compression or uncompression on a standard CCITT test page in less than .75 seconds. Expect to see this chip in all new facsimile boards; it can handle the three most popular compression and reconstruction algorithms for faxes. This chip could also be very useful in image workstation environments. An image that was stored on disk in CCITT group-3 or group-4 format could be recalled from disk, expanded, and displayed in less than a second.

Usenix

At a recent Usenix, I talked to a old, former-Bell-Labbie friend of mine. He told me that the prime developer of the C on a RISC Processor (CRISP), who was frustrated with the bureaucracy of AT&T in marketing his invention, is now employed by Sun Microsystems. This researcher is currently responsible for a Gallium Arsenide version of the Sun SPARC processor.

One of C++'s prime proponents, Andrew Koenig of AT&T Bell Laboratories, appears to be readying a book on "C traps and pitfalls," based on the subject's recent community brain dump over Usenet.

I also heard at Usenix that one of Sun's founders, hardware guru Andy Bechtolsheim, is hard at work on a machine that is targeted for the masses. Apparently, he has been working on this machine for the past two years (rumors started at the 1987 Usenix Conference in Phoenix). Codenamed "campus," this machine supposedly lies in the $3,000 to $5,000 price bracket. Is this the SPARCintosh?

Remember These Words

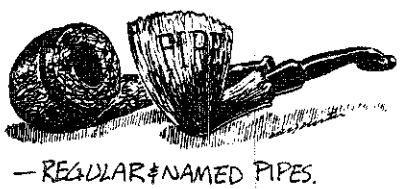
Ken Bosomworth of IRD: "I think Unix will fade away, but it may take a decade."

Amy Wohl: "At the user level I do not think that Unix will be a standard. It would be hard to list 10 or 15 good Unix workstation packages outside the field of engineering."

These people are dead wrong. ♦

Frank D. Greco is an independent consultant who offers industry analysis, systems consulting, and technological forecasting for Fortune 500 companies. Readers can contact Frank at the following address and phone number:

Frank D. Greco, c/o Crossroads Technologies, Inc., P.O. 530, Fanwood, New Jersey 07023 (201) 754-7820



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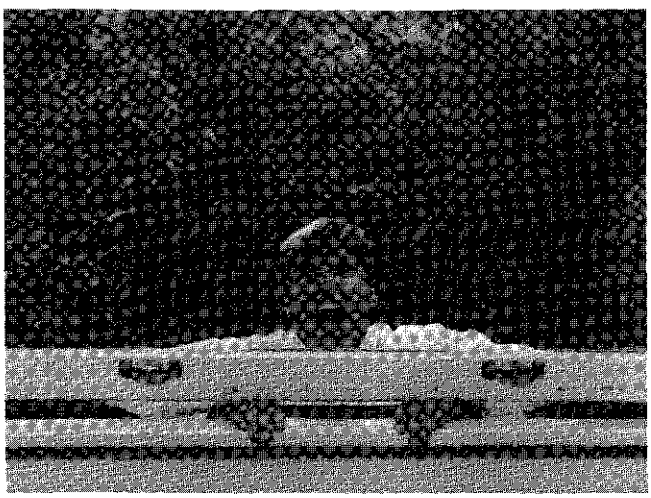

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Higher 256-Color Resolution on the VGA

by
Michael Abrash

Installment 10: In which we find the answer to the riddle "When is 320x200 really 320x400?" and chance upon some intriguing 256-color resolutions.

One of the more appealing features of the VGA is the ability to display 256 simultaneous colors. Unfortunately, one of the less appealing features of the VGA is the limited resolution (320x200) of the one 256-color mode the BIOS supports. More color can often compensate for less resolution, but the resolution difference between the 640x480 16-color mode and the 320x200 256-color mode is so great that many programmers must regretfully decide that they simply can't afford to use the 256-color mode.

If there's one thing we've learned about the VGA, however, it's that there's *never* just one way to do things. With the VGA, alternatives always exist for the clever programmer, and that's more true than you might imagine with 256-color mode. Not only is there a high 256-color resolution, there are *lots* of higher 256-color resolutions, going all the way up to 360x480! (Here I'm talking about the vanilla IBM VGA—third-party VGAs go all the way up to 800x600 256-color resolutions, but that's a story for another time.)

While I'd love to cover all of the 256-color resolutions, high-resolution 256-color programming is a fairly complex topic, and I've only so much space and time. Consequently, I'm going to take a quick look at the available 256-color resolutions and then focus on my personal favorite 256-color mode, which provides 320x400 resolution and two graphics pages and can be set up with very little reprogramming of the VGA. So. Let's get started.

Why 320x200? Only IBM Knows for Sure

The first question is, of course, How can it be possible to get higher 256-color resolutions out of the VGA? After all, there were no unused higher resolutions to be found in the CGA, Hercules card, or EGA.

The answer is another question: Why did IBM *not* use the higher-resolution 256-color modes of the VGA? The VGA is easily capable of twice the 200-scan-line vertical resolution of mode 13h, the 256-color mode, and IBM clearly made a decision not to support a higher-resolution 256-color mode. In fact, mode 13h *does* display 400 scan lines, but each row of pixels is displayed on two successive scan lines, resulting in an effective resolution of 320x200. This is the same scan-doubling approach used by the VGA to convert the CGA's 200-scan-line modes to 400 scan lines; however, because the resolution of the CGA has long been fixed at 200 scan lines, IBM had no choice with the CGA modes but to scan-double the lines. Mode 13h has no such historical limitation—it's the first 256-color mode ever offered by IBM, if you don't count the late and unlamented PGC. Why, then, would IBM choose to limit the resolution of mode 13h?

There's no way to know, but one good guess is that IBM wanted a standard 256-color mode across all PS/2 computers, and mode 13h is the highest-resolution 256-color mode that could fill the bill. You see, each 256-color pixel requires one byte of display memory, so a 320x200 256-color mode requires 64,000 bytes of display memory. That's no problem for the VGA, which has 256K of display memory, but it's a stretch for the MCGA of the Model 30, since the MCGA comes with only 64K.

On the other hand, the smaller display-memory size of the MCGA also limits the number of colors supported in 640x480 mode to 2, rather than the 16 supported by the VGA. In this case, though, IBM simply created two modes and made both available on the VGA: mode 11h for 640x480 2-color graphics and mode 12h for 640x480 16-color graphics. The same could have been done for 256-color graphics—but it wasn't. Why? I don't know. Maybe IBM just didn't like the odd aspect ratio of a 320x400 graphics mode. Heck, maybe they made a mistake in designing the chip. Whatever the reason, mode 13h is really a 400-scan-line mode masquerading as a 200-scan-line mode, and we can readily end that masquerade.

Higher 256-Color Resolutions

The VGA can actually display even higher 256-color resolutions than 320x400. Resolutions of 320x480, 360x400, and 360x480 are all possible. I'm going to take a quick look at each of the three higher resolutions and then return to the 320x400, which I think is the best of the lot.

The number of scan lines on the screen is a function of the number of vertical frames displayed each second, which in turn is controlled by the vertical timing registers of the CRT Controller (CRTC). Most VGA modes, including mode 13h, display 70 frames per second, with each frame 400 scan lines high. However, modes 11h and 12h both display sixty 480-scan-line frames per second. Getting 480 scan lines out of mode 13h (320x480 256-color mode) is a simple matter of selecting the mode and then reprogramming the vertical timing

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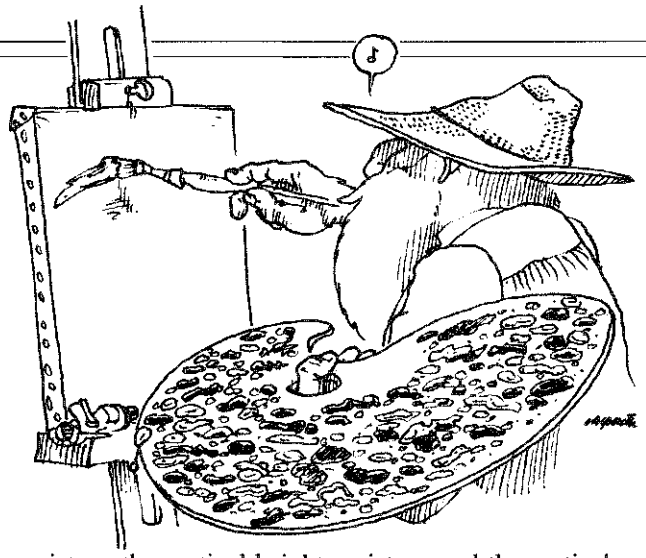

registers, the vertical height registers, and the vertical and horizontal sync polarities along the lines of mode 12h. (The sync polarities tell the VGA monitor how rapidly to scan vertically. Slower scanning is needed to allow 480 scan lines to fit on the screen.)

360x400 256-color mode requires a change in the horizontal scanning rate of the VGA. You accomplish this by selecting the faster VGA clock in the Miscellaneous Output register. This clock is normally used for scanning 720 pixels across the screen in 9-dots-per-character 80-column text modes but will serve equally well to scan 720 pixels across the screen in graphics mode in the form of ninety 8-dot characters. Of course, changing the clock speed and the number of characters per line requires reprogramming of the horizontal timing and horizontal width registers in the CRTC to match, just as changing the frame rate and number of scan lines per frame required reprogramming of the vertical timing registers. Since there is no 90-column 8-dot-per-character mode, these parameters must be calculated from scratch or by trial and error.

With VGA monitors, horizontal timings and vertical timings operate independently; so, all you need to do to get 360x480 resolution is combine the 320x480 and 360x400 256-color modes. All of these modes also require reprogramming in order to let your programs get at display memory properly, as we'll see shortly in our discussion of the 320x400 mode.

You've surely noticed that I haven't given any specifics about register values and such for selecting these higher-resolution modes. There's a good reason for that: Each of these modes comes with certain risks for the developer. For one thing, the modes with 360 pixels per scan line run the VGA's memory faster than any other VGA mode, and I don't know if that access speed is within the specs of the VGA's memory. For another, there's always danger in reprogramming the timing registers. Sure, every VGA clone claims register compatibility, but it's on just such nonstandard modes as these that compatibility tends to break.

Given the risks of the above modes, given that I have limited space, *and* given that there's a mode I consider safe and superior, I'm not going to pursue the three higher-resolution 256-color modes I've mentioned any further, at least not in this installment. Those of you who really want to use these modes should be able to figure out what to do from the thumbnail sketches I've given. If enough readers request it, however, I would be happy to devote a future installment to these three modes.

By the way, I'm probably overstating the risks of the three higher-resolution 256-color modes. I read recently that Rix is coming out with a 360x480 256-color program for the VGA. Those guys know the VGA awfully well, and they have access to just about every VGA clone in existence. If they think 360x480 256-color mode is safe enough to use in a commercial product, it's a pretty safe bet that it is.

Still and all, I like 320x400 256-color mode best. 320x400 requires very little VGA reprogramming (and none at all to the timing registers) and gives us two pages—ideal for animation and flicker-free drawing. So, it's onward to 320x400 and working code!

320x400 256-Color Mode

Okay, what's so great about 320x400 256-color mode? Two things: easy, safe mode sets and paging.

As I said above, mode 13h is really a 320x400 mode, albeit with each line doubled to produce an effective resolution of 320x200. That means that we don't need to change any display timings, widths, or heights in order to tweak mode 13h into 320x400 mode—and that makes 320x400 a safe choice. Basically, 320x400 mode differs from mode 13h only in the settings of *mode* bits, which are sure to be consistent from one VGA clone to the next and which work equally well with all monitors. The other hi-resolution 256-color modes differ from mode 13h not only in the settings of the mode bits but also in the settings of timing and dimension registers, which may not be exactly the same on all VGA clones and particularly not on all multisync monitors. (Because multisyncs can sometimes shrink or expand VGA displays, some VGAs may use alternate register settings for multisync monitors that are optimized for those monitors.)

The other good thing about 320x400 256-color mode is that two pages are supported. Since each 320x400 256-color mode requires 128,000 bytes of display memory, we can just barely manage two pages in 320x400 mode, one starting at offset 0 in display memory and the other starting at offset 8000h. Those two pages are the largest pair of pages that can fit in the VGA's 256K, though, and the higher-resolution 256-color modes, which use still larger bitmaps, can't support two pages at all. As we've seen in earlier installments of "On Graphics," paging is very useful for off-screen construction of images and fast, smooth animation.

That's why I like 320x400 256-color mode. The next step is to understand how the bitmap is organized in 320x400 mode, and that's not so simple.

Display-Memory Organization in 320x400 Mode

First, let's look at why display memory must be organized differently in 320x400 256-color mode than in mode 13h. The designers of the VGA intentionally limited the maximum size of the bitmap in mode 13h to 64K, thereby limiting resolution to 320x200. This was accomplished *in hardware*, so there is no way to extend the bitmap organization of mode 13h to 320x400 mode.

That's a shame, because mode 13h has the simplest bitmap organization of any mode—one long, linear bitmap, with each byte controlling one pixel. We can't have that organization,

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though; so we'll have to find an acceptable substitute if we want to use a higher 256-color resolution.

With the VGA, of course, there are actually *several* bitmap organizations that let us use higher 256-color resolutions than mode 13h. The one I like best is shown in Figure 1. Each byte controls one 256-color pixel. Pixel 0 is at address 0 in plane 0, pixel 1 is at address 0 in plane 1, pixel 2 is at address 0 in plane 2, pixel 3 is at address 0 in plane 3, pixel 4 is at address 1 in plane 0, and so on.

Let's look at this another way. Ideally, we'd like one long bitmap, with each pixel at the address that's just after the address of the pixel to the left. Well, that's true in this case too, *if* you consider the number of the plane that the pixel is in to be part of the pixel's address. View the pixel numbers on the screen as increasing from left to right and from the end of one scan line to the start of the next. Then the pixel number, *n*, of the pixel at display-memory address *address* in plane *plane* is

$$n = (address * 4) + plane$$

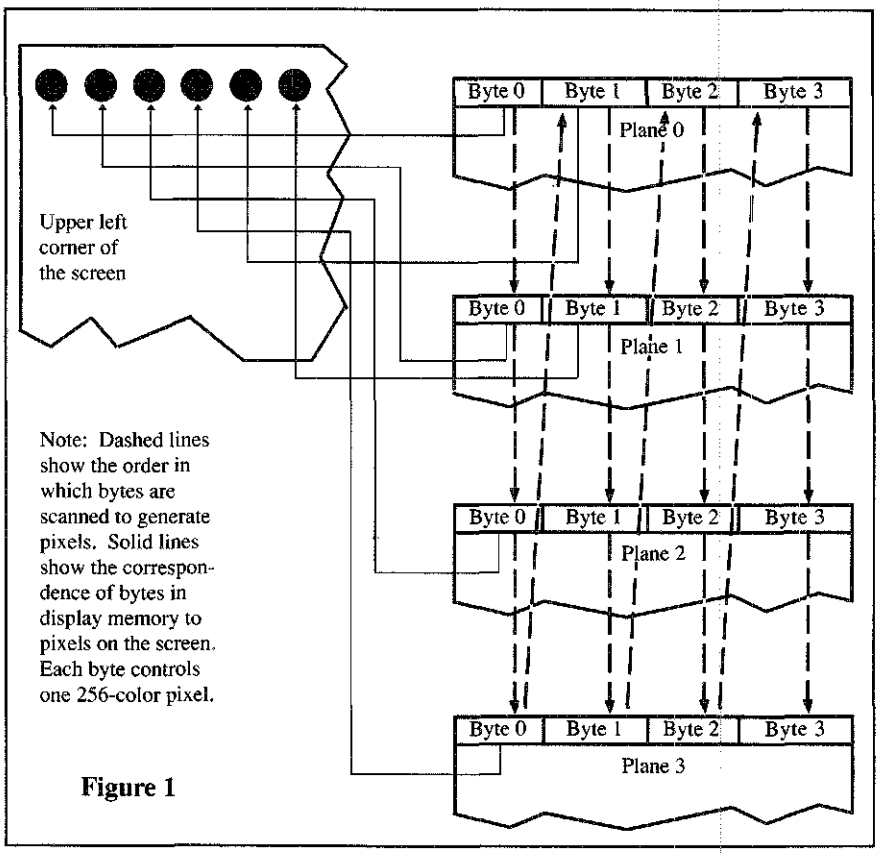
Byte 0
Byte 1
Byte 2
Byte 3
Plane 0
Plane 1
Plane 2
Plane 3
Upper left corner of the screen
Note: Dashed lines show the order in which bytes are scanned to generate pixels. Solid lines show the correspondence of bytes in display memory to pixels on the screen. Each byte controls one 256-color pixel.

Figure 1

To turn that around, the display-memory address of pixel number *n* is given by

$$address = n / 4$$

and the plane of pixel *n* is given by

$$plane = n \text{ modulo } 4$$

Basically, the full address of the pixel, its pixel number, is broken into two components: the display-memory address and the plane.

By the way, because 320x400 mode has a significantly different memory organization from mode 13h, the BIOS text routines won't work in 320x400 mode. If you want to draw text in 320x400 mode, you'll have to look up a font in the BIOS ROM and draw the text yourself. Likewise, the BIOS read pixel and write pixel routines won't work in 320x400 mode, but that's no problem: I'll provide equivalent routines in the next section.

Our next task is to convert standard mode 13h into 320x400 mode. That's accomplished by undoing many of the mode bits that are set up especially for mode 13h so that from a programming perspective the VGA reverts to a straightforward planar model of memory. That means taking the VGA out of chain-4 mode and doubleword mode, turning off the double display of each scan line, making sure chain mode, odd/even mode, and word mode are turned off, and selecting byte mode for video data display. All that's done in the Set320x400Mode subroutine in Listing 1, which we'll discuss next.

Reading and Writing Pixels

The basic graphics functions in any mode are functions to read and write single pixels. Any more-complex function can be built on these primitives, although that's not always the speediest solution. What's more, once you understand the operation of the read and write pixel functions, you've got all the knowledge you need to create functions that perform more-complex graphics functions. Consequently, we'll start our exploration of 320x400 mode with pixel-at-a-time line drawing.

Listing 1 draws eight multicolored octagons, drawing a new one on top of the old one each time a key is pressed. The main-loop code of Listing 1 should be easy to understand: A series of diagonal, horizontal, and vertical lines are drawn one pixel at a time based on a list of line descriptors, with the draw colors incremented for each successive time through the line list.

Three aspects of Listing 1 are particularly interesting:

1. The Set320x400Mode subroutine selects 320x400 256-color mode by performing a mode-13h mode set and then putting the VGA into standard planar byte mode. Set320x400Mode zeros display memory as well. It's necessary to clear display memory even after a mode-13h mode set, because the mode-13h mode set clears only the 64K of display memory that can be accessed in that mode, leaving 192K of display memory untouched.

2. The WritePixel subroutine draws a colored pixel at any *x,y* addressable location on the screen. Although it may not be obvious because I've optimized the code a little, the process of drawing a pixel is remarkably simple. First, the pixel's display-memory address is calculated as

$$address = [x * (SCREEN\_WIDTH / 4)] + (y / 4)$$

which might be more recognizable as

$$address = [(x * SCREEN\_WIDTH] + y) / 4$$

continued . . .

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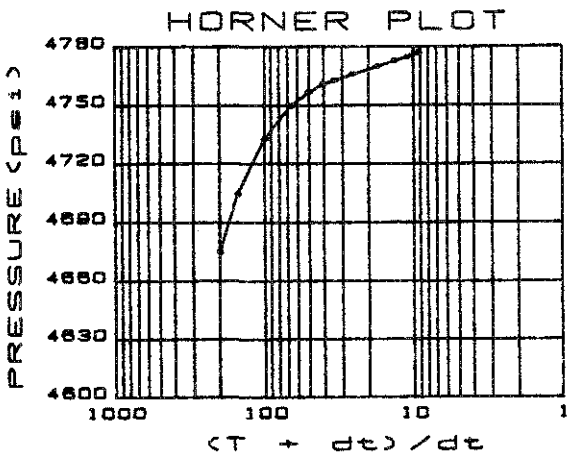

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(There are 4 pixels at each display-memory address in 320x400 mode, hence the division by 4.) Then, the pixel's plane is calculated as

$$plane = y \text{ and } 3$$

which is equivalent to

$$plane = y \text{ modulo } 4$$

The pixel's color is then written to the addressed byte in the addressed plane. That's all there is to it!

3. The ReadPixel subroutine is virtually identical to WritePixel, save that in ReadPixel the Read Map register is programmed with a plane number, while WritePixel uses a plane *mask* to set the Map Mask register. Of course, that merely reflects a fundamental difference in the operation of the two registers. (If that's Greek to you, you'll want to get back issues 5.1-5.4, 6.1, 6.2, and 6.4-6.6 of *Programmer's Journal* and come up to speed on the basics of EGA and VGA programming.) ReadPixel isn't used in Listing 1, but I've included it because, as I said above, the read and write pixel functions together can support a whole host of more-complex graphics functions.

How does 320x400 256-color mode stack up in regard to performance? As it turns out, the programming model of 320x400 mode is actually quite good for pixel drawing—very nearly on a par with the model of mode 13h. When you run Listing 1, you'll no doubt notice that the lines are drawn quite rapidly. (In fact, the drawing could be considerably faster still with a dedicated line-drawing subroutine, which would avoid the multiplication associated with each pixel in Listing 1.)

In 320x400 mode, the calculation of the memory address is not significantly slower than in mode 13h, and the calculation and selection of the target plane is quickly accomplished. As with mode 13h, 320x400 mode benefits tremendously from the byte-per-pixel organization of 256-color mode, which eliminates the need for the time-consuming pixel masking of the 16-color modes. Most important, byte-per-pixel modes never require read/modify/write operations (which can be extremely slow owing to display-memory wait states) to clip and draw pixels. To draw a pixel, you just store its color in display memory. What could be simpler?

More-sophisticated operations than pixel drawing are less easy to accomplish in 320x400 mode, but with a little ingenuity it is possible to implement an efficient version of just about any useful graphics function. A fast line draw for 320x400 mode would be simple, and fast image copies could be implemented by copying one quarter of the image to one plane, one quarter to the next plane, and so on for all four planes. If you're really into performance, you could store your images with all the bytes for plane 0 grouped together, followed by all the bytes for plane 1, and so on. That would allow a single rep movs instruction to copy all the bytes for a given plane, with just four rep movs instructions copying the whole image.

It's all a bit complicated, but as I say, you should be able to design a fast version for 320x400 mode of whatever graphics function you need. If you're not all that concerned with speed, WritePixel and ReadPixel should meet your needs.

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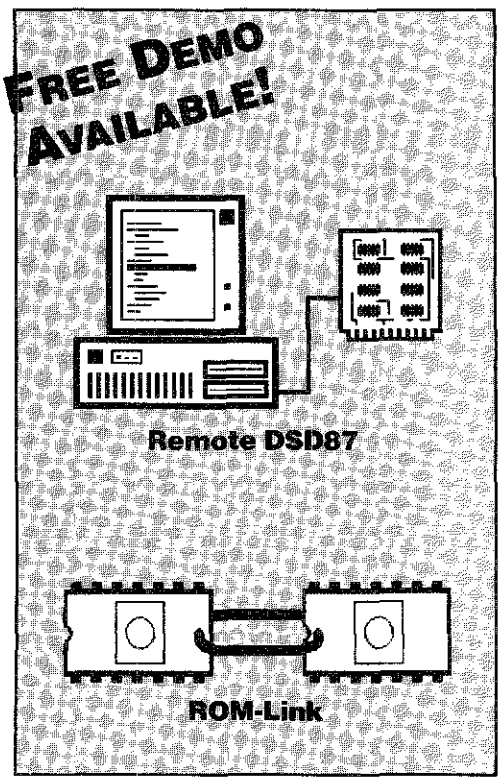

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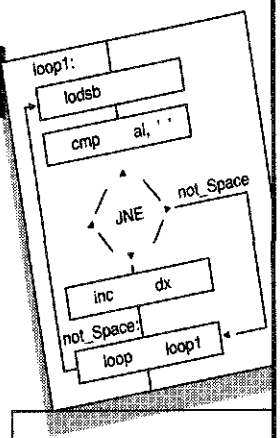

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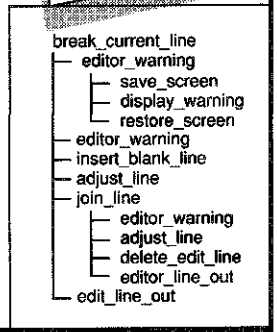

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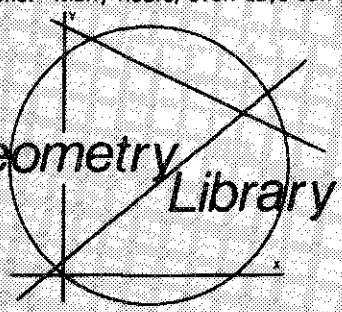

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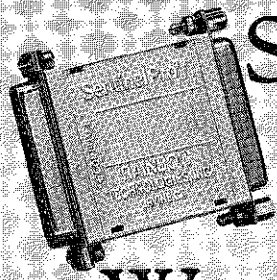

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Two 256-Color Pages

Listing 2 demonstrates the two pages of 320x400 256-color mode by drawing slanting color bars in page 0, drawing color bars slanting the other way in page 1, and flipping to page 1 on the next key press. (Note that page 1 is accessed starting at offset 8000h in display memory, and is—not surprisingly—displayed by setting the start address to 8000h.) Finally, Listing 2 draws vertical color bars in page 0 and flips back to page 0 when another key is pressed.

The color bar routines don't use the WritePixel subroutine from Listing 1; they go straight to display memory instead for improved speed. As I mentioned above, yet better speed could be achieved by a color bar algorithm that draws all the pixels in plane 0, then all the pixels in plane 1, and so on, thereby avoiding the overhead of constantly reprogramming the Map Mask register.

When you run Listing 2, note the extremely smooth edges and fine gradations of color, especially in the screens with slanting color bars. The displays produced by Listing 2 make it clear that 320x400 256-color mode can produce effects that are simply not possible in the 16-color modes.

Something to Think About

You can, if you wish, use the display-memory organization of 320x400 mode in 320x200 mode by modifying Set320x400Mode to leave the maximum scan line setting at 1 in the mode set. (The version of Set320x400Mode in listings 1 and 2 forces the maximum scan line to 0, doubling the effective resolution of the screen.) Why would you want to do that? Simply because you could then choose from, not two, but *four* 320x200 256-color display pages, starting at offsets 0, 4000h, 8000h, and 0C000h in display memory.

In Conclusion

Who knows what resolutions lurk in the hearts of VGAs? Now you do. What an adapter, eh?

As always, I'm not sure what's next on the list for "On Graphics." Also as always, I'm open to your suggestions; drop me a line via MCI or the U.S. mail.

See you next time. ♦

Michael Abrash is a Senior Software Engineer for Orion Instruments, Inc., of Redwood City, California, where he is working on the design of advanced PC-based test instrumentation. Readers may write to Michael at P.O. Box 39051, Mountain View, CA 94039, or drop Michael a line via MCI Mail (user name MABRASH).

Code follows.

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Mail order information on pages 8 and 88.

Code from "256-Color Resolution" by Michael Abrash

1

```
;
; *** Listing 1 ***
;
; Program to demonstrate pixel drawing in 320x400 256-color
; mode on the VGA. Draws 8 lines to form an octagon, a pixel
; at a time. Draws 8 octagons in all, one on top of the other,
; each in a different color set. Although it's not used, a
; pixel read function is also provided.
;
VGA_SEGMENT     equ     0a000h
SC_INDEX        equ     3c4h    ;Sequence Controller Index register
GC_INDEX        equ     3ceh    ;Graphics Controller Index register
CRTC_INDEX      equ     3d4h    ;CRT Controller Index register
MAP_MASK        equ     2       ;Map Mask register index in SC
MEMORY_MODE     equ     4       ;Memory Mode register index in SC
MAX_SCAN_LINE   equ     9       ;Maximum Scan Line reg index in CRTC
START_ADDRESS_HIGH equ  0ch     ;Start Address High reg index in CRTC
UNDERLINE       equ     14h     ;Underline Location reg index in CRTC
MODE_CONTROL    equ     17h     ;Mode Control register index in CRTC
READ_MAP        equ     4       ;Read Map register index in GC
GRAPHICS_MODE   equ     5       ;Graphics Mode register index in GC
MISCELLANEOUS   equ     6       ;Miscellaneous register index in GC
SCREEN_WIDTH    equ     320     ;# of pixels across screen
SCREEN_HEIGHT   equ     400     ;# of scan lines on screen
WORD_OUTS_OK    equ     1       ;set to 0 to assemble for
                              ; computers that can't handle
                              ; word outs to indexed VGA registers
;
stack   segment para stack 'STACK'
        db      512 dup (?)
stack   ends
;
Data    segment word 'DATA'
;
BaseColor       db      0
;
; Structure used to control drawing of a line.
;
LineControl     struc
StartX          dw      ?
StartY          dw      ?
LineXInc        dw      ?
LineYInc        dw      ?
BaseLength      dw      ?
LineColor       db      ?
LineControl     ends
;
; List of descriptors for lines to draw.
;
LineList        label   LineControl
        LineControl     <130,110,1,0,60,0>
        LineControl     <190,110,1,1,60,1>
        LineControl     <250,170,0,1,60,2>
        LineControl     <250,230,-1,1,60,3>
        LineControl     <190,290,-1,0,60,4>
        LineControl     <130,290,-1,-1,60,5>
        LineControl     <70,230,0,-1,60,6>
        LineControl     <70,170,1,-1,60,7>
        LineControl     <-1,0,0,0,0,0>
Data    ends
;
; Macro to output a word value to a port.
;
OUT_WORD        macro
if WORD_OUTS_OK
        out     dx,ax
else
        out     dx,al
        inc     dx
        xchg    ah,al
        out     dx,al
        dec     dx
        xchg    ah,al
endif
        endm
;
; Macro to output a constant value to an indexed VGA register.
;
CONSTANT_TO_INDEXED_REGISTER    macro   ADDRESS, INDEX, VALUE
        mov     dx,ADDRESS
        mov     ax,(VALUE shl 8) + INDEX
        OUT_WORD
        endm
;
Code    segment
        assume  cs:Code, ds:Data
Start   proc    near
        mov     ax,Data
        mov     ds,ax
;
;Set 320x400 256-color mode.
;
        call    Set320x400Mode
;
; We're in 320x400 256-color mode. Draw each line in turn.
;
ColorLoop:
        mov     si,offset LineList ;point to the start of the
                                   ; line descriptor list
LineLoop:
        mov     cx,[si+StartX]  ;set the initial X coordinate
        cmp     cx,-1
        jz      LinesDone       ;a descriptor with a -1 X
                                ; coordinate marks the end
                                ; of the list
        mov     dx,[si+StartY]     ;set the initial Y coordinate,
        mov     bl,[si+LineColor]  ; line color,
        mov     bp,[si+BaseLength] ; and pixel count
        add     bl,[BaseColor]  ;adjust the line color according
                                ; to BaseColor
PixelLoop:
        push    cx              ;save the coordinates
        push    dx
        call    WritePixel      ;draw this pixel
        pop     dx              ;retrieve the coordinates
        pop     cx
        add     cx,[si+LineXInc] ;set the coordinates of the
        add     dx,[si+LineYInc] ; next point of the line
        dec     bp              ;any more points?
        jnz     PixelLoop       ;yes, draw the next
        add     si,size LineControl ;point to the next line descriptor
        jmp     LineLoop        ; and draw the next line
LinesDone:
        call    GetNextKey      ;wait for a key, then
        inc     [BaseColor]     ; bump the color selection and
        cmp     [BaseColor],8   ; see if we're done
        jb      ColorLoop       ;not done yet
;
; Wait for a key and return to text mode and end when
; one is pressed.
;
        call    GetNextKey
        mov     ax,0003h
        int     10h     ;text mode
        mov     ah,4ch
        int     21h     ;done
;
Start   endp
;
; Sets up 320x400 256-color modes.
;
; Input: none
;
; Output: none
;
Set320x400Mode  proc    near
;
; First, go to normal 320x200 256-color mode, which is really a
; 320x400 256-color mode with each line scanned twice.
;
        mov     ax,0013h  ;AH = 0 means mode set, AL = 13h selects
```

Code continues . . .

2

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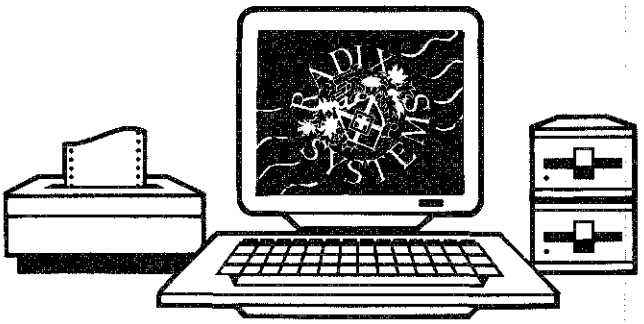

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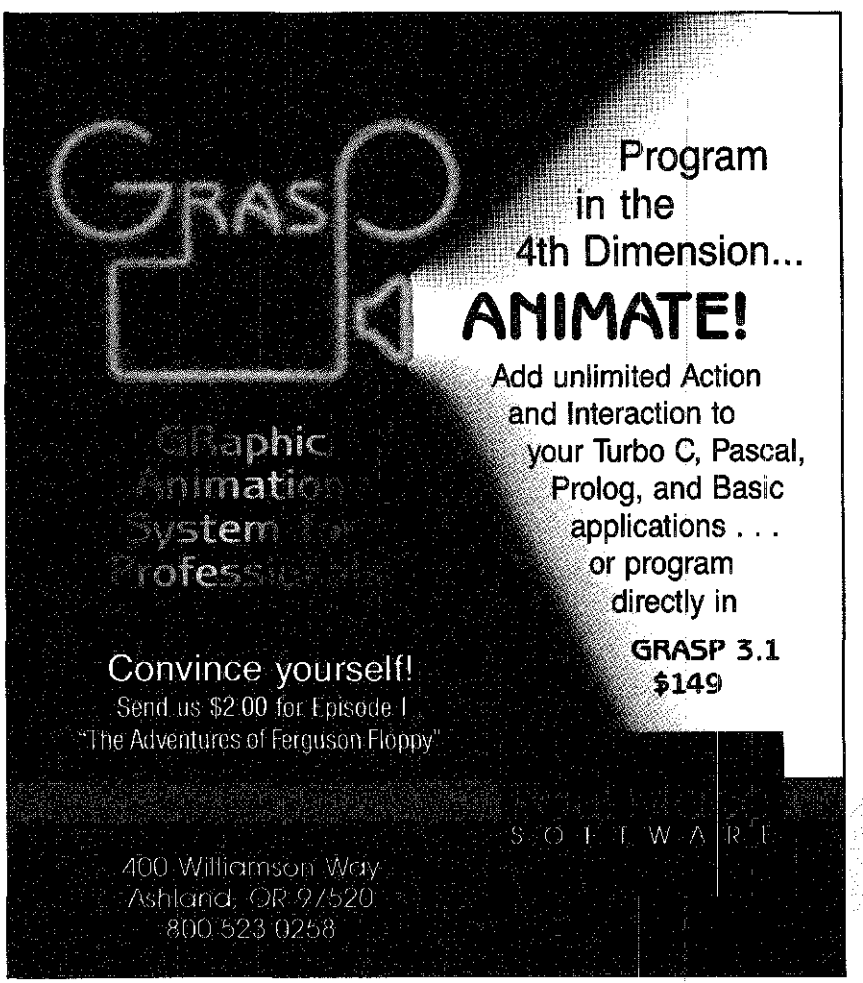

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3

```
                        ; 256-color graphics mode
        int     10h     ;BIOS video interrupt
;
; Change CPU addressing of video memory to linear (not odd/even,
; chain, or chain 4), to allow us to access all 256K of display
; memory. When this is done, VGA memory will look just like memory
; in modes 10h and 12h, except that each byte of display memory will
; control one 256-color pixel, with 4 adjacent pixels at any given
; address, one pixel per plane.
;
        mov     dx,SC_INDEX
        mov     al,MEMORY_MODE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 08h      ;turn off chain 4
        or      al,04h          ;turn off odd/even
        out     dx,al
        mov     dx,GC_INDEX
        mov     al,GRAPHICS_MODE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 10h      ;turn off odd/even
        out     dx,al
        dec     dx
        mov     al,MISCELLANEOUS
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 02h      ;turn off chain
        out     dx,al
;
; Now clear the whole screen, since the mode 13h mode set only
; cleared 64K out of the 256K of display memory. Do this before
; we switch the CRTC out of mode 13h, so we don't see garbage
; on the screen when we make the switch.
;
        CONSTANT_TO_INDEXED_REGISTER SC_INDEX,MAP_MASK,0fh
                                ;enable writes to all planes, so
                                ; we can clear 4 pixels at a time
        mov     ax,VGA_SEGMENT
        mov     es,ax
        sub     di,di
        mov     ax,di
        mov     cx,8000h        ;# of words in 64K
        cld
        rep     stosw           ;clear all of display memory
;
; Tweak the mode to 320x400 256-color mode by not scanning each
; line twice.
;
        mov     dx,CRTC_INDEX
        mov     al,MAX_SCAN_LINE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 1fh      ;set maximum scan line = 0
        out     dx,al
        dec     dx
;
; Change CRTC scanning from doubleword mode to byte mode, allowing
; the CRTC to scan more than 64K of video data.
;
        mov     al,UNDERLINE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 40h      ;turn off doubleword
        out     dx,al
        dec     dx
        mov     al,MODE_CONTROL
        out     dx,al
        inc     dx
        in      al,dx
        or      al,40h  ;turn on the byte mode bit, so memory is
                        ; scanned for video data in a purely
                        ; linear way, just as in modes 10h and 12h
        out     dx,al
```

4

```
        ret
Set320x400Mode endp
;
; Draws a pixel in the specified color at the specified
; location in 320x400 256-color mode.
;
; Input:
;       CX = X coordinate of pixel
;       DX = Y coordinate of pixel
;       BL = pixel color
;
; Output: none
;
; Registers altered: AX, CX, DX, DI, ES
;
WritePixel      proc    near
        mov     ax,VGA_SEGMENT
        mov     es,ax ;point to display memory
        mov     ax,SCREEN_WIDTH/4
                        ;there are 4 pixels at each address, so
                        ; each 320-pixel row is 80 bytes wide
                        ; in each plane
        mul     dx      ;point to start of desired row
        push    cx      ;set aside the X coordinate
        shr     cx,1    ;there are 4 pixels at each address
        shr     cx,1    ; so divide the X coordinate by 4
        add     ax,cx   ;point to the pixel's address
        mov     di,ax
        pop     cx      ;get back the X coordinate
        and     cl,3    ;get the plane # of the pixel
        mov     ah,1
        shl     ah,cl   ;set the bit corresponding to the plane
                        ; the pixel is in
        mov     al,MAP_MASK
        mov     dx,SC_INDEX
        OUT_WORD        ;set to write to the proper plane for
                        ; the pixel
        mov     es:[di],bl      ;draw the pixel
        ret
WritePixel      endp
;
; Reads the color of the pixel at the specified location in 320x400
; 256-color mode.
;
; Input:
;       CX = X coordinate of pixel to read
;       DX = Y coordinate of pixel to read
;
; Output:
;       AL = pixel color
;
; Registers altered: AX, CX, DX, SI, ES
;
ReadPixel       proc    near
        mov     ax,VGA_SEGMENT
        mov     es,ax   ;point to display memory
        mov     ax,SCREEN_WIDTH/4
                        ;there are 4 pixels at each address, so
                        ; each 320-pixel row is 80 bytes wide
                        ; in each plane
        mul     dx      ;point to start of desired row
        push    cx      ;set aside the X coordinate
        shr     cx,1    ;there are 4 pixels at each address
        shr     cx,1    ; so divide the X coordinate by 4
        add     ax,cx   ;point to the pixel's address
        mov     si,ax
        pop     ax      ;get back the X coordinate
        and     al,3    ;get the plane # of the pixel
        mov     ah,al
        mov     al,READ_MAP
        mov     dx,GC_INDEX
        OUT_WORD        ;set to read from the proper plane for
                        ; the pixel
        lods    byte ptr es:[si] ;read the pixel
        ret
ReadPixel       endp
;
; Waits for the next key and returns it in AX.
;
```

Code continues . . .

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Abrash Code, Continued

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```
; Input: none
;
; Output:
;       AX = full 16-bit code for key pressed
;
GetNextKey      proc    near
WaitKey:
        mov     ah,1
        int     16h
        jz      WaitKey ;wait for a key to become available
        sub     ah,ah
        int     16h     ;read the key
        ret
GetNextKey      endp
;
Code    ends
;
        end     Start


;
; *** Listing 2 ***
;
; Program to demonstrate the two pages available in 320x400
; 256-color modes on a VGA.  Draws diagonal color bars in all
; 256 colors in page 0, then does the same in page 1 (but with
; the bars tilted the other way), and finally draws vertical
; color bars in page 0.
;
VGA_SEGMENT     equ     0a000h
SC_INDEX        equ     3c4h    ;Sequence Controller Index register
GC_INDEX        equ     3ceh    ;Graphics Controller Index register
CRTC_INDEX      equ     3d4h    ;CRT Controller Index register
MAP_MASK        equ     2       ;Map Mask register index in SC
MEMORY_MODE     equ     4       ;Memory Mode register index in SC
MAX_SCAN_LINE   equ     9       ;Maximum Scan Line reg index in CRTC
START_ADDRESS_HIGH equ  0ch     ;Start Address High reg index in CRTC
UNDERLINE       equ     14h     ;Underline Location reg index in CRTC
MODE_CONTROL    equ     17h     ;Mode Control register index in CRTC
GRAPHICS_MODE   equ     5       ;Graphics Mode register index in GC
MISCELLANEOUS   equ     6       ;Miscellaneous register index in GC
SCREEN_WIDTH    equ     320     ;# of pixels across screen
SCREEN_HEIGHT   equ     400     ;# of scan lines on screen
WORD_OUTS_OK    equ     1       ;set to 0 to assemble for
                                ; computers that can't handle
                                ; word outs to indexed VGA registers
;
stack   segment para stack 'STACK'
        db      512 dup (?)
stack ends
;
; Macro to output a word value to a port.
;
OUT_WORD        macro
if WORD_OUTS_OK
        out     dx,ax
else
        out     dx,al
        inc     dx
        xchg    ah,al
        out     dx,al
        dec     dx
        xchg    ah,al
endif
        endm
;
; Macro to output a constant value to an indexed VGA register.
;
CONSTANT_TO_INDEXED_REGISTER    macro   ADDRESS, INDEX, VALUE
        mov     dx,ADDRESS
        mov     ax,(VALUE shl 8) + INDEX
        OUT_WORD
        endm
;
Code    segment
        assume  cs:Code
Start   proc    near
;
; Set 320x400 256-color mode.
```

6

```
;           call    Set320x400Mode
;
; We're in 320x400 256-color mode, with page 0 displayed.
; Let's fill page 0 with color bars slanting down and to the right.
;
        sub     di,di           ;page 0 starts at address 0
        mov     bl,1            ;make color bars slant down and
                                ; to the right
        call    ColorBarsUp     ;draw the color bars
;
; Now do the same for page 1, but with the color bars
; tilting the other way.
;
        mov     di,8000h        ;page 1 starts at address 8000h
        mov     bl,-1           ;make color bars slant down and
                                ; to the left
        call    ColorBarsUp     ;draw the color bars
;
; Wait for a key and flip to page 1 when one is pressed.
;
        call    GetNextKey
        CONSTANT_TO_INDEXED_REGISTER CRTC_INDEX,START_ADDRESS_HIGH,80h
                                ;set the Start Address High register
                                ; to 80h, for a start address of 8000h
;
; Draw vertical bars in page 0 while page 1 is displayed.
;
        sub     di,di           ;page 0 starts at address 0
        sub     bl,bl           ;make color bars vertical
        call    ColorBarsUp     ;draw the color bars
;
; Wait for another key and flip back to page 0 when one is pressed.
;
        call    GetNextKey
        CONSTANT_TO_INDEXED_REGISTER CRTC_INDEX,START_ADDRESS_HIGH,00h
                                ;set the Start Address High register
                                ; to 00h, for a start address of 0000h
;
; Wait for yet another key and return to text mode and end when
; one is pressed.
;
        call    GetNextKey
        mov     ax,0003h
        int     10h     ;text mode
        mov     ah,4ch
        int     21h     ;done
;
Start   endp
;
; Sets up 320x400 256-color modes.
;
; Input: none
;
; Output: none
;
Set320x400Mode  proc    near
;
; First, go to normal 320x200 256-color mode, which is really a
; 320x400 256-color mode with each line scanned twice.
;
        mov     ax,0013h  ;AH = 0 means mode set, AL = 13h selects
                          ; 256-color graphics mode
        int     10h     ;BIOS video interrupt
;
; Change CPU addressing of video memory to linear (not odd/even,
; chain, or chain 4), to allow us to access all 256K of display
; memory. When this is done, VGA memory will look just like memory
; in modes 10h and 12h, except that each byte of display memory will
; control one 256-color pixel, with 4 adjacent pixels at any given
; address, one pixel per plane.
;
        mov     dx,SC_INDEX
        mov     al,MEMORY_MODE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 08h      ;turn off chain 4
        or      al,04h          ;turn off odd/even
        out     dx,al
```

Code continues . . .

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7

```
        mov     dx,GC_INDEX
        mov     al,GRAPHICS_MODE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 10h      ;turn off odd/even
        out     dx,al
        dec     dx
        mov     al,MISCELLANEOUS
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 02h      ;turn off chain
        out     dx,al

;
; Now clear the whole screen, since the mode 13h mode set only
; cleared 64K out of the 256K of display memory. Do this before
; we switch the CRTC out of mode 13h, so we don't see garbage
; on the screen when we make the switch.
;
        CONSTANT_TO_INDEXED_REGISTER SC_INDEX,MAP_MASK,0Fh
                                        ;enable writes to all planes, so
                                        ; we can clear 4 pixels at a time
        mov     ax,VGA_SEGMENT
        mov     es,ax
        sub     di,di
        mov     ax,di
        mov     cx,8000h        ;# of words in 64K
        cld
        rep     stosw           ;clear all of display memory

;
; Tweak the mode to 320x400 256-color mode by not scanning each
; line twice.
;
        mov     dx,CRTC_INDEX
        mov     al,MAX_SCAN_LINE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 1fh      ;set maximum scan line = 0
        out     dx,al
        dec     dx

;
; Change CRTC scanning from doubleword mode to byte mode, allowing
; the CRTC to scan more than 64K of video data.
;
        mov     al,UNDERLINE
        out     dx,al
        inc     dx
        in      al,dx
        and     al,not 40h      ;turn off doubleword
        out     dx,al
        dec     dx
        mov     al,MODE_CONTROL
        out     dx,al
        inc     dx
        in      al,dx
        or      al,40h  ;turn on the byte mode bit, so memory is
                        ; scanned for video data in a purely
                        ; linear way, just as in modes 10h and 12h
        out     dx,al
        ret
Set320x400Mode  endp
;
; Draws a full screen of slanting color bars in the specified page.
;
; Input:
;       DI = page start address
;       DL = 1 to make the bars slant down and to the right, -1 to
;            make them slant down and to the left, 0 to make
;            them vertical.
;
ColorBarsUp     proc    near
        mov     ax,VGA_SEGMENT
        mov     es,ax   ;point to display memory
        sub     bh,bh   ;start with color 0
        mov     si,SCREEN_HEIGHT ;# of rows to do
        mov     dx,SC_INDEX
        mov     al,MAP_MASK
        mov     ah,bh   ;start with color 0
```

Code continues . . .

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Abrash Code, Continued

```
        out     dx,al   ;point the SC Index reg to the Map Mask reg
        inc     dx      ;point DX to the SC Data register
RowLoop:
        mov     cx,SCREEN_WIDTH/4
                        ;there are 4 pixels at each address, so
                        ; each 320-pixel row is 80 bytes wide
                        ; in each plane
        push    bx      ;save the row-start color
ColumnLoop:
MAP_SELECT = 1
        rept    4       ;do all 4 pixels at this address with
                        ; in-line code
        mov     al,MAP_SELECT
        out     dx,al   ;select planes 0, 1, 2, and 3 in turn
        mov     es:[di],bh ;write this plane's pixel
        inc     bh      ;set the color for the next pixel
MAP_SELECT = MAP_SELECT shl 1
        endm
        inc     di      ;point to the address containing the next
                        ; 4 pixels
        loop    ColumnLoop ;do any remaining pixels on this line
        pop     bx      ;get back the row-start color
        add     bh,bl   ;select next row-start color (controls
                        ; slanting of color bars)
        dec     si      ;count down lines on the screen
        jnz     RowLoop
        ret
ColorBarsUp     endp
;
; Waits for the next key and returns it in AX.
;
GetNextKey      proc    near
WaitKey:
        mov     ah,1
        int     16h
        jz      WaitKey ;wait for a key to become available
        sub     ah,ah
        int     16h     ;read the key
        ret
GetNextKey      endp
;
Code    ends
;
        end     Start
```


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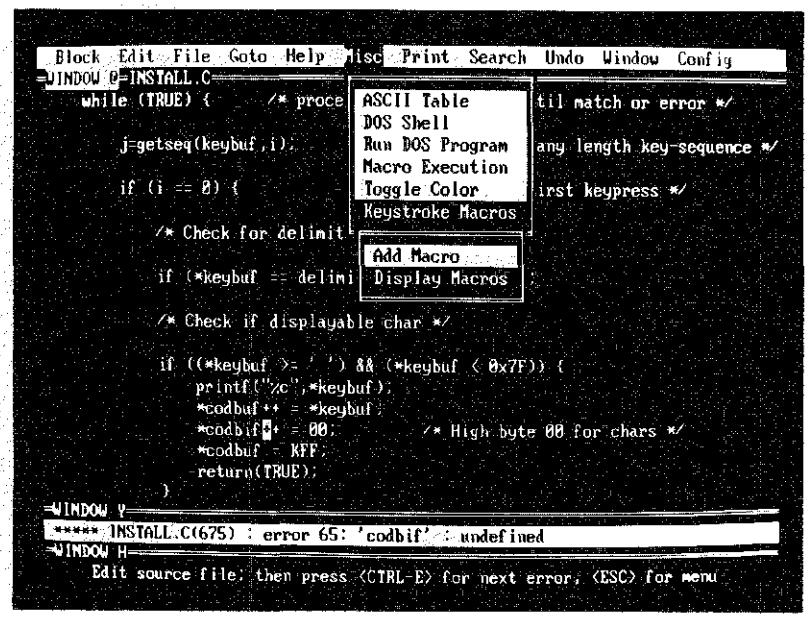
Block Edit File Goto Help Misc Print Search Undo Window Config
WINDOW 0 INSTALL.C
while (TRUE) { /* proce til match or error */
j=getseq(keybuf,i); any length key-sequence */
if (i == 0) { irst keypress */
/* Check for delimit
if (*keybuf == delimi
/* Check if displayable char */
if ((*keybuf >= ' ') && (*keybuf < 0x7F)) {
printf("%c",*keybuf);
*codbuf++ = *keybuf;
codbuf++ = 00; / High byte 00 for chars */
*codbuf = KFF;
return(TRUE);
}
ASCII Table
DOS Shell
Run DOS Program
Macro Execution
Toggle Color
Keystroke Macros
Add Macro
Display Macros
WINDOW 9
***** INSTALL.C(675) : error 65: 'codbif' : undefined
WINDOW H
Edit source file, then press <CTRL-E> for next error, <ESC> for menu

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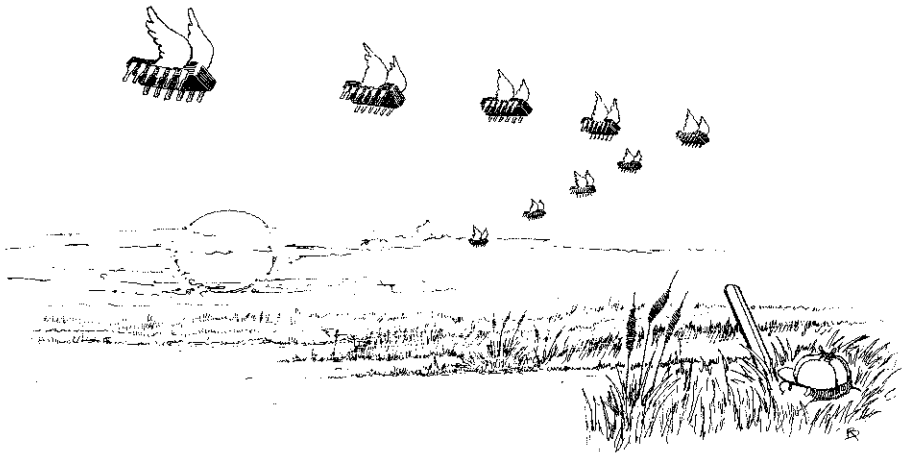
Migrating to Graphics Processors



by
Jake Richter

Graphics processors are slowly infiltrating the world around us. They can be found in laser printers, plotters, computer terminals, video games, and, of course, on graphics boards.

With the recent announcement of the Texas Instruments TMS 34020 Graphics System Processor, a second-generation graphics processor, these pieces of silicon have come of age. This indication of TI's commitment to affordable, high-speed graphics will help provide a larger market in which programmers who understand this technology can sell their skills. Since the largest consumer of graphics processors is the video board industry, I feel appropriate presenting an overview of the two leading graphic processors and how they are used in a video environment.

The two processors I am referring to are the Intel 82786 and the TI TMS 34010 (pronounced "three-forty-ten"). Both were announced almost three years ago, and both offer incredible functionality. The reason for the rising popularity of graphics processors is their ability to handle the substantial effort of drawing lines, circles, and other primitives, thereby freeing up the system processor for other tasks. This concept is known as *distributed processing*.

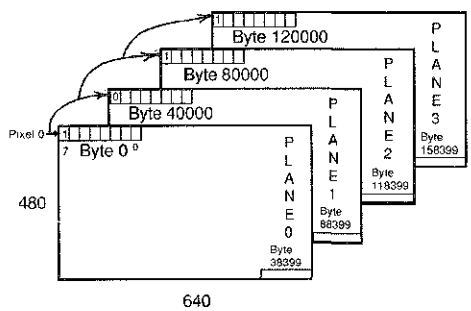
If you are familiar with the fundamental concepts behind EGA and VGA graphics, you know that the higher-resolution EGA/VGA modes use a "cross-plane" architecture. The cross-plane mode is a technique used by IBM to allow access to approximately 128K worth of graphics memory through a 64K window to reduce potential memory conflicts and properly utilize the segmentation of the 80x86 architecture. The other graphics modes, both the CGA-compatible and the special 8-bit mode, use a different architecture, known as *packed pixel*.

Plotting pixels in a cross-plane architecture generally requires that a couple of registers be set and, in some cases, that two memory writes occur. On the other hand, setting pixels in a packed pixel architecture may require a read/modify/write operation, but only when the pixel size is smaller than the data bus width.

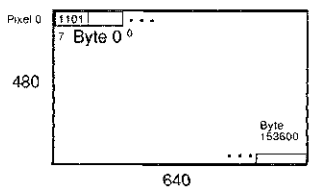
Most high-end graphics boards use the packed pixel architecture because it is more suitable for image-processing operations and because it tends to be easier to manage the much greater amount of memory required by high resolutions. This also applies to many graphics processors, including the 34010 and the 82786. In order to get around the 64K-segment problem, many of these high-end video boards use bank switching, which allows a block of memory, usually 16K or 64K, to be mapped into the PC's address space. If a program needs to address a pixel that is not accessible in the currently mapped block of memory, it just maps in the correct block and performs its work. This procedure is analogous to working with expanded memory. I was surprised that IBM didn't use this approach with the EGA when they were developing it, and now they have doomed themselves to maintaining backward compatibility.

One "standard" that seems to be different for each type of graphics product is pixel order in memory. Both the 34010 and the 82786 use an external data bus 16 bits wide; pixels are ordered within a word. The 82786 stores pixels starting in the most significant part of a word; just to confuse things, the 34010 stores

Pixel 0 is a 4-bit pixel with a value of 13_{10} (1101_2) in both cases (planar and packed).
Pixel can be selected by using a combination of bit and plane masks, and writes to plane 0.



Sample planar architecture



Sample packed pixel architecture

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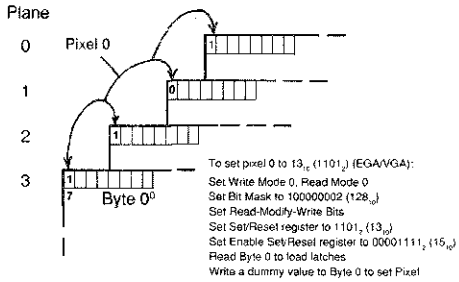
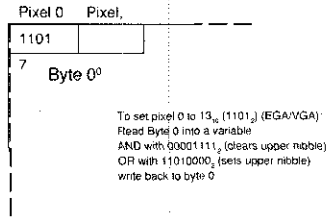

Plane
0
1
2
3
Pixel 0
Byte 0⁰
To set pixel 0 to 13₁₆ (1101₂) (EGA/VGA):
Set Write Mode 0, Read Mode 0
Set Bit Mask to 100000002 (128₁₀)
Set Read-Modify-Write Bits
Set Set/Reset register to 1101₂ (13₁₀)
Set Enable Set/Reset register to 00001111₂ (15₁₀)
Read Byte 0 to load latches
Write a dummy value to Byte 0 to set Pixel

Setting a pixel in a cross-plane mode (Y bits per pixel)


Pixel 0
Pixel,
1101
Byte 0⁰
To set pixel 0 to 13₁₆ (1101₂) (EGA/VGA):
Read Byte 0 into a variable
AND with 00001111₂ (clears upper nibble)
OR with 11010000₂ (sets upper nibble)
write back to byte 0

Setting a pixel in packed pixel mode

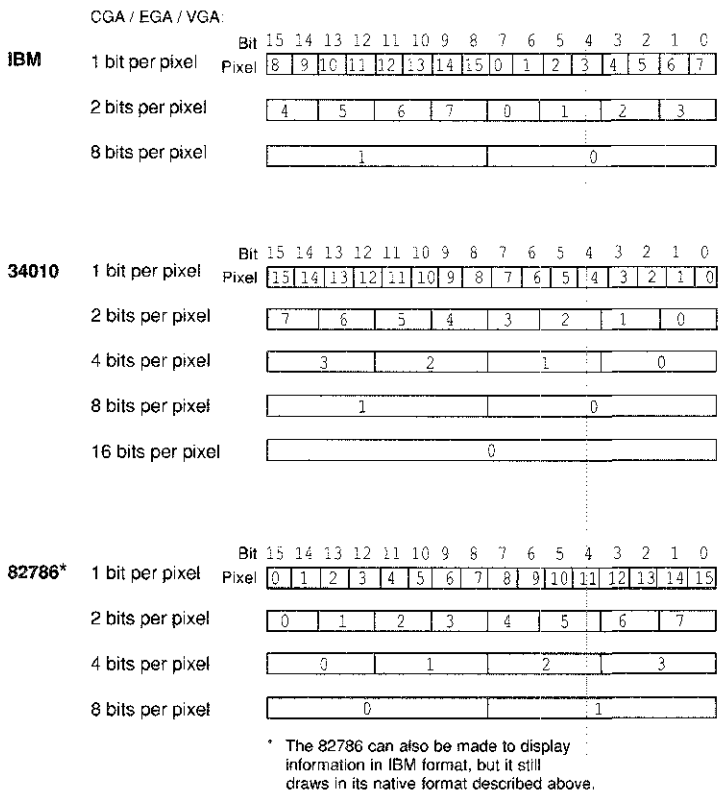
pixels starting in the least significant portion. [To make matters even worse, the PC standard (CGA/EGA/VGA) packed-pixel formats use another variation.] This makes a big difference when transferring data from one to the other.

This difference is just the start. Many people make the mistake of trying to compare the 82786 and 34010 head-on. This sort of comparison is invalid because the 34010 is a fully functional processor, whereas the 82786 is a coprocessor, similar in concept to a numeric coprocessor. This being the case, it's best to examine each processor in some detail.

The 34010

With VGA boards supporting graphics at 1, 2, 4, and 8 bits per pixel—and PC developers just starting to understand the possibilities—it may be surprising that the 34010 supports 16-bit-per-pixel drawing in addition to the depths supported by the VGA. The 34010's architecture lends itself to graphics because it addresses memory in bits. Conventional processors, such as the 8086, address memory in bytes. Bit addressing assists graphics operations by allowing individual pixels to be located and modified.

Of course, another component is required: data width. The 34010 provides a feature known as "fields." Each instruction that accesses memory must use one of the two field registers to determine how many bits wide the memory access should be. Fields can specify a width of 1 to 32 bits. Although this feature is transparent, it is not without some cost. Since the 34010's external data bus


CGA / EGA / VGA:
IBM
1 bit per pixel
2 bits per pixel
8 bits per pixel
Bit 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Pixel 8 9 10 11 12 13 14 15 0 1 2 3 4 5 6 7
4 5 6 7 0 1 2 3
1 0
34010
1 bit per pixel
2 bits per pixel
4 bits per pixel
8 bits per pixel
16 bits per pixel
Bit 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Pixel 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
7 6 5 4 3 2 1 0
3 2 1 0
1 0
0
82786*
1 bit per pixel
2 bits per pixel
4 bits per pixel
8 bits per pixel
Bit 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Pixel 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
0 1 2 3
0 1
* The 82786 can also be made to display information in IBM format, but it still draws in its native format described above.

Visual packed pixel representations within a word (16 bits)

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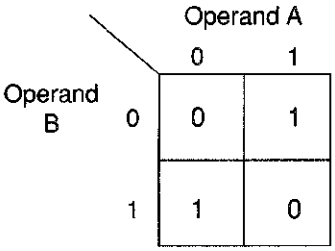

XOR Truth Table

$A = 37_{16}$. $B = F8_{16}$

A XOR B = CF_{16}

A XOR CF_{16} = $F8_{16}$ (same as B)

B XOR CF_{16} = 37_{16} (same as A)

Example of using XOR twice to recover previous values.

is 16 bits wide (the internal bus is 32 bits wide), any memory access that does not start on a word boundary and is not 16 bits wide will take slightly longer to execute.

The 34010 has two clock inputs: One, the pixel clock, drives the video output; the other is used as the system clock. TI is currently producing 40-, 50-, and 60-MHz 34010s. (Before you get all excited, note that the clock speed is divided by 8 before being used to time instruction cycles.)

In addition to an instruction set somewhat reminiscent of the PDP-11's, the 34010 has several instructions that were designed specifically for graphics operations:

FILL	Fills a rectangular area of memory with the foreground color.
PIXBLT	Moves a rectangular block of memory to another memory location. PIXBLT stands for PIXel BLock Transfer.
LINE	Draws a line.
DRAV	Provides incremental drawing support. DRAV (draw advance) is used to implement graphics primitives, such as circles and arcs.

The 34010 has thirty-one 32-bit data registers, split into two groups. TI refers to these groups as "register files." Register file A contains the general-purpose registers, and register file B contains the function-dependent registers. One of these 31 registers, the stack

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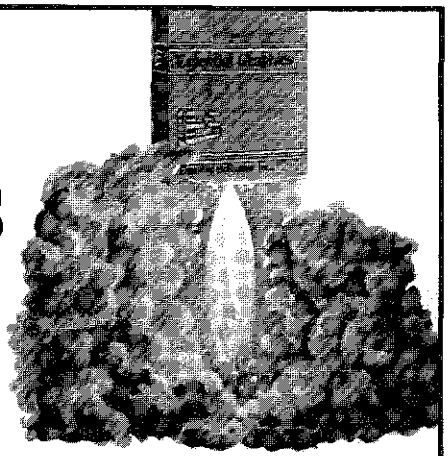

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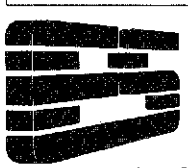

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pointer, appears in both register files, thereby creating the impression that each file has 16 registers. The graphics instructions do not use the field registers.

The B-file registers specify such things as the display start address, FILL dimensions, and foreground and background colors. The field registers referred to earlier are actually located in the status register, along with standard processor status flags. Another dedicated pair of registers in the B file consists of the source and destination pitch registers, which specify the number of bits that should be added to an address in order to end up at the same horizontal (x) position on the next sequential line. These are necessary for most graphical primitives that are not limited to operating on only one scan line. Unfortunately, a restriction on the pitch values requires that they be a power of 2; because of this, a 640x480 display will actually take up enough memory for a 1024x480 display, even though only 640 pixels will appear. This restriction is removed in the 34020.

Another set of registers, known as the I/O Control registers, are responsible for video control and some other special graphics operations, such as write-protecting bit planes and supporting logical writing modes. These registers are accessed by reading or writing to a specific area in the memory map.

Logical writing modes are arithmetic operations that act upon drawing functions. One commonly used logical writing mode is XOR mode. It is used to draw pixels in such a way that when the same sequence of pixel is drawn again, the contents of memory are restored to their original settings. This writing mode is used for drawing cursors, among other purposes.

Table 1 lists all the logical writing modes. The first 16 are also supported by the 82786.

Because the 34010 is really a 32-bit processor, it has the potential of addressing up to 4 gigabits (512 megabytes) of memory. (Actually, only 128Mb of memory can be addressed in the 34010, owing to some hardware limitations, but the 34020 will have access to the full 512Mb.) This may seem like an immense address space, but when you consider that a 640x480 8-bit display takes up 480K (remember the pitch limitation), you realize that graphics eats up memory altogether too quickly.

The 34010 has the advantage of being able to accept intelligent, nongraphics tasks from the PC. This means that in a properly designed application, you could put some of the device-independent functions (those that don't require access to PC devices, such as drives or keyboards) onto a 34010 while the PC goes off to do something else that may be more critical. I am not trying to imply that you can directly execute 8086 code on the 34010—code for the 34010 is best developed using the TI C Compiler and Assembler, a much more pleasant alternative to hand coding.

Although this is a rather rough overview of the 34010, it should give you a taste of its capabilities. My sources claim that 100 thousand 34010s were shipped last year (with that amount to double this year), and most of these chips are ending up on graphics boards. Some companies that utilize the 34010 on their graphics boards are TI, Number Nine, Renaissance GRX, Matrox, NEC, PC Tech, and Imagraph.

The Intel 82786

As I mentioned earlier, the 82786 is a graphics coprocessor, which, in this context, means that it is capable of executing hard-wired graphics primitives but not general-purpose code. The disadvantage of a coprocessor is obvious: You need an external processor to feed the 82786 its commands. The external processor also has to run the code that performs the more complex graphics operations, such as flood fills. This will obviously consume more of the host processor's bandwidth, but it still outperforms working with a "dumb buffer" (unassisted) board.

The 82786 is, surprisingly enough, a more complex design than the 34010. This is due to the '786 actually consisting of three separate (but interacting) processors: the Graphics Processor (GP), the Display Processor (DP), and the Bus Interface Unit (BIU). The BIU controls all access to the chip as well as to the memory it manages (up to 4Mb). The accesses can come from three sources—the GP, DP, and any external processors—and they can be assigned priorities, as well.

The GP is the processor that actually handles all the drawing primitives. The GP's hard-wired primitives are fast, because the chip was designed specifically with that set of functions in mind. In addition to the listed primitives, the '786 supports line patterns, the 16 logical writing modes discussed earlier, a plane mask, and pixel transparency. These operations are all supported at 1, 2, 4, and 8 bits per pixel.

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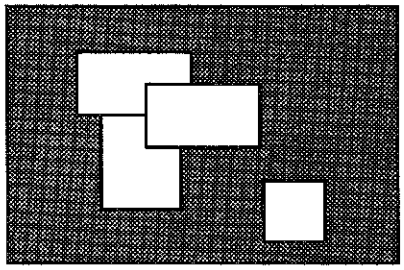
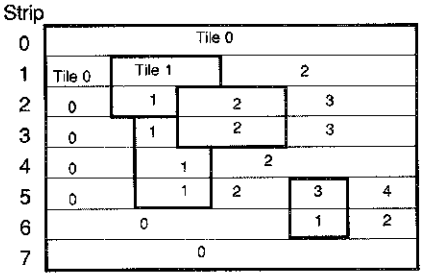


Shaded area is field, i.e., not data.

What you see on screen, 4 hardware windows



8 strips, with 1 to 5 tiles each

Strip and tile breakdown of an 82786 screen

programmability is severely limited. It does have CALL and RETURN commands, though; so you could set up a generic command list to, for example, draw a box with an *X* in it at the current *x,y* position and make it a subroutine that you could call in from your 82786 "program."

The Display Processor is probably the most underutilized feature of the chip. Most graphics-board companies using the 82786 use the DP for driving the monitor output and not much else. But the DP provides two other features: a hardware cursor and hardware windowing.

Hardware windows are similar in concept to the overlapping software windows utilized in such packages as Microsoft Windows. The big difference is that hardware windows do not require a redraw of screen information when the window is moved. This means that you can have virtually simultaneous drawing going on in a number of overlapping windows without worrying about clipping, because the hardware windows only display what's in memory; they do not alter memory. Hardware windows can also display *field*, a term used to indicate non–memory consuming display information ("dead space"). Because all normal limitations are removed, the long-time tie between memory and display is completely altered, requiring programmers to toss out everything they know about displaying PC-based graphics.

Of course, you can still use the one-to-one correlation between memory and display by creating a full-screen hardware window. Hardware windows are rectangular tiles that display data from memory at 1, 2, 4, or 8 bits per pixel. To top that off, a window can be flagged to indicate to the hardware that it should be zoomed. The zoom factor ranges from 1 to 64 in both the *x* and *y* directions. The screen position of a hardware window as well as the contents are determined by the DP display list. This display list consists of a series of strips, each of which contains a number of tiles. There is a limit of 15 tiles per strip, but no limit on the number of strips, providing each one is at least one scan line high.

Although the 82786 is a coprocessor, it does have three sets of registers that can be accessed by an external processor. One set belongs to the DP and is used for setting display frequencies, display list location, cursor pattern, and so forth. Another set belongs to the GP and contains information regarding the current drawing environment, such as *x,y* position, colors, and start of drawing area in memory. The last set of registers is the set containing the processor control. This set can be either memory

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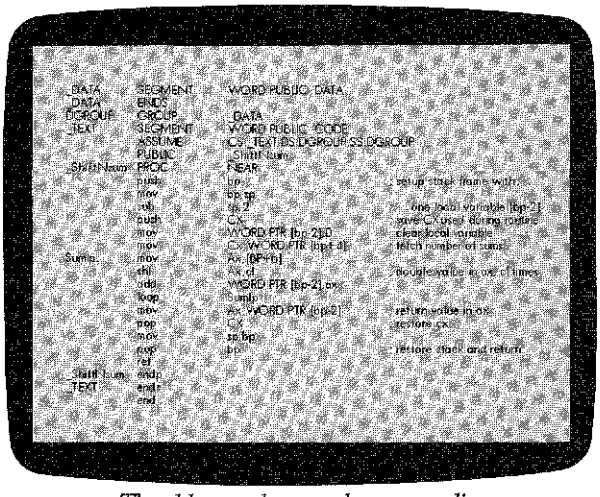

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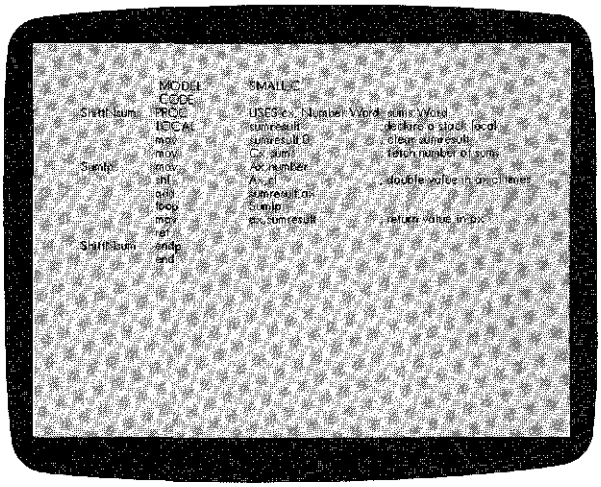

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mapped or I/O mapped and allows the external processor to initialize the chip and send commands to the GP and DP.

Some companies that offer boards based on the 82786 are Autograf, Bell Technologies, and Verticom. Also, Number Nine offers a board that sports both an 82786 and a 34010.

Interfacing with the Processors

As you may be able to tell, there is a big difference in the way these processors are programmed. In order to take full advantage of their special features, you must access them directly.

If you do not need these special capabilities but still want to access the high drawing speed that these processors offer, you may want to consider some interfaces offered by various companies. These interfaces include such packages as MetaWindows by Metagraphics, DGIS and CGI from Graphics Software Systems, and HALO by Media Cybernetics. The problem with using packages like these is that they have to support a large variety of graphics products, all with different capabilities; therefore, they have had to use the most common features to define their interfaces. On the other hand, board-specific software interfaces, such as Renaissance GRX's RGDI or Number Nine's NNIOS, give you access to board-specific features, but only for the boards of their respective companies. One newly announced interface, TIGA-340 from TI, may help standardize the writing of software for boards based on the TI 340X0 series of processors.

Looking Ahead

We know where TI is going with their graphics-processor line: The 34020 has a 32-bit bus (internal and external) and supports faster drawing operations and a floating-point processor, the 34082—you can actually attach up to seven of them. It has a slew of other enhancements, as well. The question is, Where is Intel heading? At this point, Intel has given no official word, but I have a feeling we'll be seeing something high powered and graphics related in the near future.

Numerous companies have realized that the graphics-processor market is maturing into a full-fledged industry and have, therefore, come up with their own entries into the market. Among these are several RISC processors from such companies as AMD and Weitek, as well as some drawing accelerators from National Semiconductor and Cirrus Logic. Information has appeared in trade journals about silicon-level clones of the 8514/A. None of these has been taken too seriously by board manufacturers yet, but only time will tell for sure.

EGA and VGA may be the current graphics hardware standards, but they are limited in their growth. New hardware with high-speed drawing abilities is required to allow users to migrate to higher resolutions and greater color selection. The hardware is already on the horizon, but it needs support in the form of software that takes advantage of the capabilities offered. ♦

Jake Richter is president of Panacea, Inc., a PC consulting firm specializing in graphics processors. Readers may contact Jake on MCI Mail or BIX, user name JRICHTER.

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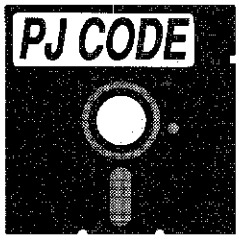

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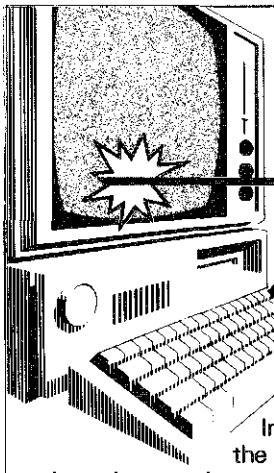

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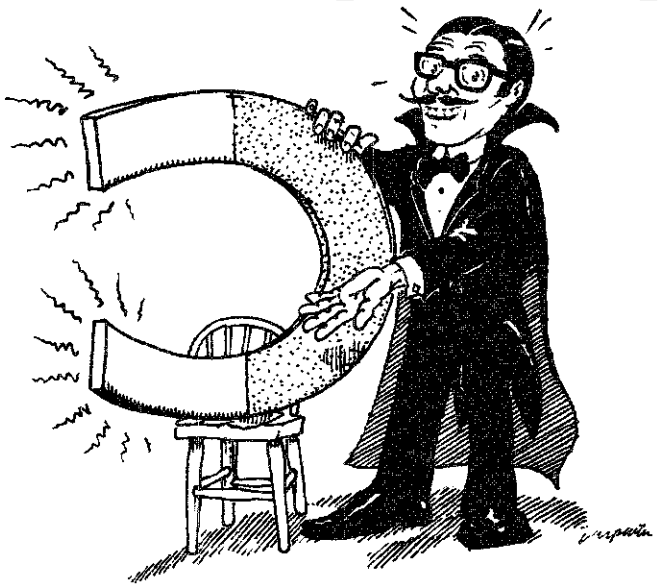
Demagnetizing Static Variables

by
Tom Swan



Modifying typed constants (alias static variables) stored in Turbo Pascal 4.0 and 5.0 compiled EXE code files is hairy business—but it can be done if you're careful.

Static variables, or typed constants as Turbo Pascal calls them, stick to compiled code like magnets to iron. Declared as constants but compiled as variables, typed constants are stored on disk inside a program's EXE code file. Because typed constants have predefined values, they eliminate wasteful initializations of global variables at runtime. Despite this advantage, however, after compiling, there's no easy way to change a program's typed constants—for example, to let people make keyboard assignments, select window colors, and modify other default settings.

A telephone call from a reader prompted me to think of several possible solutions to this problem. I knew I'd have to locate the typed constants embedded in the compiled code file and modify only the necessary bytes, storing the result back on disk with all other bytes intact. Mucking around with EXE disk files gives me the heebie-jeebies, so the code would have to be reasonably immune to changes in future compiler versions. The program should run fast, be easy to modify, work with both small and large applications, wash the floor, dust the shelves, and take out the garbage.

The following describes the results of my experiments, largely successful although I'm still doing the floor, shelves, and garbage by hand. After a brief refresher course on typed constants as stored on disk and in memory, I'll explain how to use the accompanying library unit to write custom installation programs. Also included are demonstration programs that you can use as starting places for your own projects.

A Needle in a Byte Stack

Finding typed constants in memory and on disk isn't nearly so difficult as finding a needle in you-know-what. Let's start with values in memory, as these are the easiest to locate. The first typed constant in memory is always stored at offset zero in the data segment. (There is only one data segment in a Turbo Pascal program.) Suppose you have these declarations:

```
const
  aword : word = 1024;
  achar : char = 'X';
  abyte : byte = 15;
```

The typed constant **aword** is stored at DSeg:0000, occupying two bytes. After this comes **achar** at DSeg:0002. Next, **abyte** follows at DSeg:0003. **DSeg** is a predeclared constant equal to the value of register DS. Rather than calculate these offsets manually, use the **Ofs** function to find the address of any typed constant. For example, this displays the offset addresses of the three typed constants in memory:

```
writeln(
  ' aword=', ofs(aword),
  ' achar=', ofs(achar),
  ' abyte=', ofs(abyte) );
```

In Turbo Pascal 4.0, typed constant values follow each other with no wasted bytes in-between. As a result, lone byte values can lead to extra CPU machine cycles by forcing words to begin at odd addresses. If you insert a fourth typed constant word between **achar** and **abyte**, the new value resides at DSeg:0003, making the CPU work harder to access the value. To fix this problem, Turbo Pascal 5.0 provides a new switch, **{$A+}**, to align typed constants and other variables on even addresses, letting the CPU access 16-bit quantities as quickly as possible. (Word alignment offers no advantage on PCs with 8088 processors.) The default is **{$A-}**, for no alignment.

We Are Not Alone

Your typed constants are not alone in memory. The System unit, containing Turbo Pascal's runtime library and linked into every compiled program, declares its own set of typed constants. (The 5.0 *Reference Guide* lists these on page 125.) In memory, items in the data segment follow this order:

1. Program typed constants
2. Unit typed constants
3. System typed constants
4. Global variables

The main program's typed constants are always first, beginning at offset zero. Next come any typed constants, declared in units that the program lists in a USES declaration. Then come the System unit's typed constants, followed by the program's global variables. Together, these four items make

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up the program's data segment, which can be as large as 64K. Items 1–3 are stored in the compiled EXE code file. Memory for global variables (item 4) is allocated at runtime—global variables are never stored in the disk code file.

Smart Linker; Dumb Programmer

Turbo Pascal's smart and crafty linker, which attempts to optimize compiled code, requires you to refer to at least one typed constant declared in your program and in all units. If you don't, the linker realizes you aren't using the typed constants and does not reserve space for them in the code! While writing codeless test programs to determine where typed constants are stored, it took me longer than I care to reveal to realize the linker was "helping" me by throwing my constants away. The following short program demonstrates how Turbo's smart-aleck linker can get you into trouble, as it did me:

```
program test;
const
  atc:char='a';
begin
  writeln( atc );
  writeln(
   char( ptr(dseg,0 )^) )
end.
```

The program declares one typed constant, **atc**. Two **writeln** statements display **atc**'s value, the letter *a*. The first **writeln** refers to **atc** by name. The second refers to **atc** the hard way, dereferencing a pointer to DSeg:0000 and recasting as type **Char**, admittedly the long way around a simple job. Take out the first **writeln** statement and guess what happens. The second **writeln** no longer displays *a*! Turbo Pascal throws out **atc** because it doesn't realize that the **ptr** expression refers to the typed constant.

Obviously, you won't usually refer to typed constants this way, but you might write a program that expects another module to reference a typed-constant array or large record at DSeg:0000. Don't do this. Turbo Pascal does not save typed constants unless you refer by name to at least one in each module. The same rule goes for typed constants in units. Either the unit code or another module must refer to at least one typed constant by name, or else the linker throws these babies out with the bathwater.

Sniffing for Typed Constants

Turbo Pascal stores typed constants as the last bytes in a disk code file. At runtime, the bytes are copied to the start of the program's data segment in memory. On disk and in memory, the bytes are paragraph aligned—that is, beginning at an offset in the code file and at an address in memory evenly divisible by 16.

The problem of writing an installation program to modify default values in compiled disk code files requires finding the offset to the first byte of the first typed constant. Listing 1 (WINDGLOB.PAS) makes this easy by declaring a marker *CBase* assigned the string value '@CBASE@'. The program's default settings follow **CBase**—in this sample, the typed constants **WBForeColor** to **WTitle**. Last, a dummy typed constant **EBase** marks the end of the typed constants area. **Ebase**'s data type and value are unimportant, but **CBase** must be a string.

Because the application and installation program refer to the same values, it's best to declare all typed constants in a separate unit similar to WINDGLOB.PAS. In this example, the unit has no code, although it certainly could.

The next step is to write the main application, WINDTEST.PAS in Listing 2. This program lists WINDGLOB in a USES declaration, importing the typed constants from Listing 1. Run WINDTEST to display a simple window with scrolling random characters. Press any key to end the program.

The last job is to write the installation program, which modifies the typed constant default values in the compiled WINDTEST.EXE program. Listing 3 (WINDINST.PAS) displays a menu to let you change window colors and type a new window title string. The next section describes how to compile and run the programs.

Compiling the Test Programs

First compile Listing 4, TCUNIT.PAS, creating TCUNIT.TPU. (With the integrated Turbo Pascal compiler, be sure the Compile menu's Destination option is set to "Disk.") TCUNIT has procedures to help you write your own installation programs and contains a function to locate and modify typed constant values in compiled EXE files. I'll explain how to use the unit in a moment.

After compiling TCUNIT, compile WINDGLOB.PAS to WINDGLOB.TPU. Then compile WINDTEST.PAS and run the test application. Finally, compile WINDINST.PAS and run it. Change any of the values listed in the menu. In this no-frills version, you have to specify colors by number even though WINDGLOB.PAS declares the default colors by name, using identifiers declared in the standard **Crt** unit. Press Q to quit and modify WINDTEST.EXE. Press X to quit and not save changes. Run WINDTEST again to see the effect of your new values.

How TCUnit Works

Two procedures in TCUNIT, **GetWord** and **GetStr**, prompt for word and string values. WINDINST calls these procedures to let you enter new values for various typed constants. You'll probably want to add your own procedures to prompt for values of other types, such as **GetInteger**, **GetChar**, **GetReal**, and so forth. Use the two procedures listed here as guides.

Function **ChangesSaved** in TCUNIT does all the work of opening the compiled EXE code file, locating the typed constants, and writing the modified values back to disk. See the end of WINDINST for an example call to this function, which requires a file name, the **CBase** marker string, and the offset addresses of the **CBase** and **EBase** typed constants. **ChangesSaved** performs several operations:

First the EXE file is opened. Parameter **fileName** must be the name of a compiled EXE file with **CBase** and **EBase** typed

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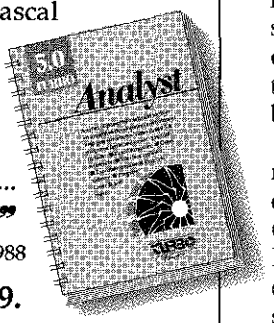

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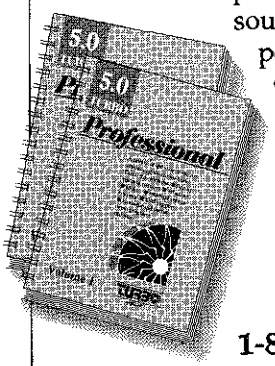

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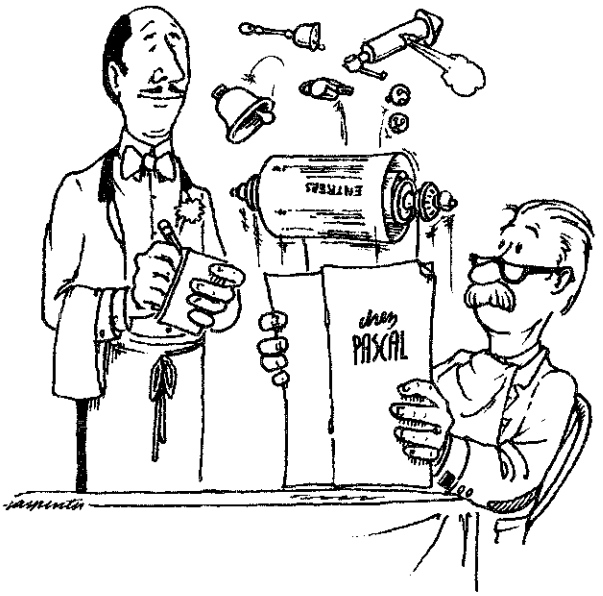

constants around the values to be modified, as shown in the listing of WINDGLOB.PAS.

Next, function **FoundCBase** returns **true** if the **CBase** marker string is found in the EXE code file. If so, **FoundCBase** returns the byte offset to this string. If not, **FoundCBase** returns **false**, causing an error message to be displayed.

If **CBase** is found, procedure **SaveData** copies the in-memory typed constants to the compiled EXE code file, overwriting only the bytes from **CBase** to the byte just before **EBase**. No other bytes are changed in the disk code file.

For all this to work correctly, you must be sure to use the identical typed constants in both the main (WINDTEST) and installation (WINDINST) programs. The safest bet is to declare all typed constants in one separate unit (WINDGLOB) and then use the unit in both programs.

Writing Your Own Installers

Even without fully understanding every detail about how TCUNIT operates, it's easy to write your own installation programs. Just follow these steps:

1. You don't have to modify TCUNIT, although you might want to add procedures to prompt for specific data types, as mentioned earlier.
2. Store all typed constants in a separate unit and compile. Start with **CBase** and end with **EBase**, as in the listing WINDGLOB.PAS. The number, type, names, and values of typed constants in between **CBase** and **EBase** are completely up to you.
3. Write your application, using the unit of typed constants from step 2. Compile to disk.
4. Write your installation program, using WINDINST.PAS as a guide. Add TCUNIT and your typed constants unit to the program's USES statement. Call **ChangesSaved** to write modified values to your program's code file.

By the way, you can also use WINDINST to modify its own code file, WINDINST.EXE. This displays the modified settings the next time you run the installation program. Also, the **CBase** marker string (see WINDGLOB.PAS) can be anything you like—it doesn't have to be '@CBASE@', as it is here. The string must be unique, occurring nowhere else

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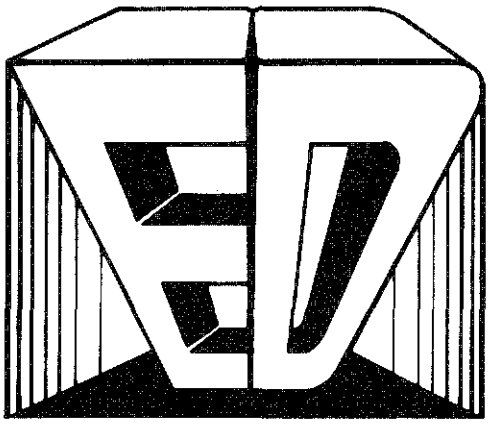

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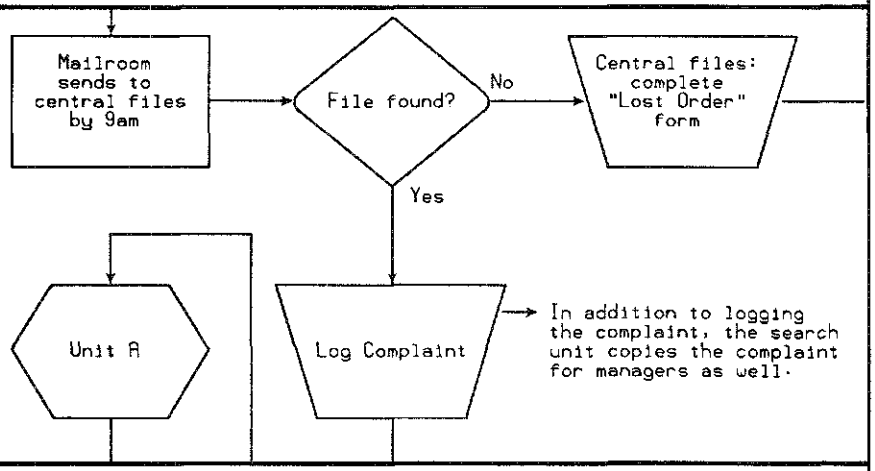
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in the code file. You might change **CBase** to your name or copyright. Then, if someone tries to remove your notice from the code file, the installation program will no longer work. Sneaky, no?

Improving the Programs

When you run these tests, you'll notice that WINDINST pauses for several seconds while hunting for **CBase** in the compiled code. There's a simple way to reduce this time. First, remove the (* and *) comment brackets from the two **writeln** statements inside TCUNIT's **FoundCBase** function. Recompile WINDINST, and press Q. Jot down the reported offset. When I did this, I got 4768, although your number is likely to be different. The value is decimal, not hex.

Edit TCUNIT.PAS again, and replace the comment brackets in **FoundCBase**. Then change the double IF statement in **ChangesSaved** near the end of the program to read:

```
IF err=0 THEN
 SaveData(f,4768,...)
```

In other words, replace variable **offset** with the value you noted earlier and remove the call to **FoundCBase**. Now when you compile and run WINDINST, the disk update takes place almost instantaneously, as TCUNIT no longer has to hunt for the offset to **CBase**.

Perform this step only after compiling your main program for the last time. (Is there ever a last time?) Any changes to your typed constants or to the program require you to recalculate the offset in the code file. Using the wrong offset is almost sure to lead to a crash.

Although these ideas and test programs are experimental, I'm planning to use them as the basis for an installation program in my Turbo Pascal database system as well as in other programs. In the past, I've found many uses for typed constants, but I'm planning to work them in more frequently, especially now that I have a way to demagnetize their previously all-too-static values. ♦

Tom Swan is the author of Mastering Turbo Pascal 2nd Edition *(1988, Howard W. Sams) and other books and is now slaving away on* Mastering Turbo Assembler, *due out early in 1989. Tom is a contributing editor for* Programmer's Journal *and* PC World.

Code follows.

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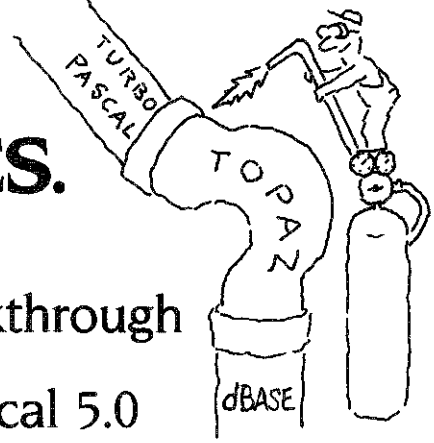

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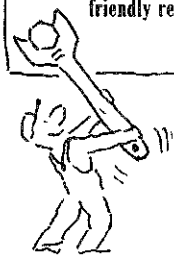

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Code from "Static Variables" by Tom Swan

1

Listing 1: WINDGLOB.PAS

```
{ WindTest, WindInst typed constants (TC) }

UNIT WindGlob;


INTERFACE

USES  Crt;

CONST

   CBase : String[7] = '@CBASE@';      { Mark beginning of TC area }
{----- Start of default typed-constants area }
   WBForeColor : Word = Blue;          { Border foreground color }
   WBBackColor : Word = LightGray;     { Border background color }
   WTForeColor : Word = Yellow;        { Text foreground color }
   WTBackColor : Word = Blue;          { Text background color }
   WTitle : String[40] = ' Test Window ';  { Window title }
{----- End of default typed-constants area }
   EBase : Char = '!';                 { Mark end of TC area }


IMPLEMENTATION

{ No code in this unit }
END.
```

Listing 2: WINDTEST.PAS

```
{ WindTest application in Turbo Pascal 4.0/5.0 by Tom Swan }

PROGRAM WindTest;


USES  Crt, WindGlob;


PROCEDURE WriteAt( x, y : Word; ch : Char );

{ Display character ch at text display location (x,y) }

BEGIN
   GotoXY( x, y );
   Write( ch )
END; { WriteAt }


PROCEDURE DrawBox( left, top, right, bottom : Word );

{ Outline a box on the text display }

VAR   i : Integer;      { FOR-loop control variable }

BEGIN
   WriteAt( left, top, #213 );
   WriteAt( right, top, #184 );
   WriteAt( left, bottom, #192 );
   WriteAt( right, bottom, #217 );
   FOR i := left+1 TO right-1 DO
```

2

```
   BEGIN
      WriteAt( i, top, #205 );
      WriteAt( i, bottom, #196 )
   END; { for }
   FOR i := top+1 TO bottom-1 DO
   BEGIN
      WriteAt( left, i, #179 );
      WriteAt( right, i, #179 )
   END { for }
END; { DrawBox }


PROCEDURE CenterTitle( s : String; left, top, right : Word );

{ Center string s at row = top between left and right }

VAR   k : Integer;   { Spaces to offset title from left }

BEGIN
   k := ( ( ( right - left ) + 1 ) - Length( s ) ) DIV 2;
   GotoXY( left + k, top );
   Write( s )
END; { CenterTitle }


PROCEDURE OpenWindow( left, top, right, bottom : Word; title : String );

{ Display blank window, restricting subsequent text output to within
the window's borders. }

BEGIN
   TextColor( WBForeColor );
   TextBackground( WBBackColor );
   DrawBox( left, top, right, bottom );
   CenterTitle( title, left, top, right );
   Window( left+1, top+1, right-1, bottom-1 )
END; { OpenWindow }


BEGIN
   ClrScr;
   OpenWindow( 10, 3, 50, 12, WTitle );
   TextColor( WTForeColor );
   TextBackground( WTBackColor );
   ClrScr;
   WHILE NOT Keypressed DO
   BEGIN
      Delay( 15 );  { "Slow down, you move too fast..." }
      Write( Chr( 32 + Random(144) ) )
   END; { while }
   Window( 1, 1, 80, 25 );
   GotoXY( 1, 25 )
END.
```

Listing 3: WININST.PAS

```
{ WindTest installer in Turbo Pascal 4.0/5.0 by Tom Swan }

PROGRAM WindInst;


USES  Crt, TCUnit, WindGlob;

CONST FileName = 'WINDTEST.EXE';    { File to modify }

VAR   userQuits : Boolean;          { True to end program }
```

Code continues . . .

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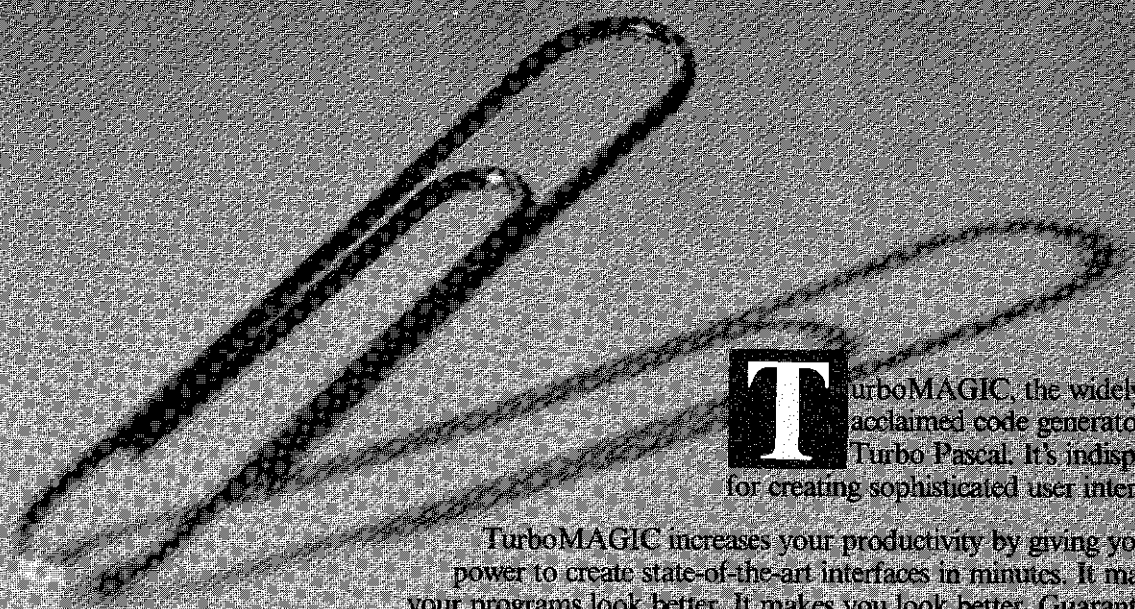

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Swan Code, Continued

3

```
FUNCTION MenuChar : Char;

{ Display menu and return selection }

BEGIN
   ClrScr;
   Writeln( 'WindTest Installation Program' );
   Writeln( '-------------------------------------' );
   Writeln( 'A - Border foreground ..... ', WBForeColor:2 );
   Writeln( 'B - Border background ..... ', WBBackColor:2 );
   Writeln( 'C - Text foreground ....... ', WTForeColor:2 );
   Writeln( 'D - Text background ....... ', WTBackColor:2 );
   Writeln( 'E - Window title .......... ', WTitle );
   Writeln;
   Writeln( 'Q - Quit and save changes' );
   Writeln( 'X - Quit and do NOT save changes' );
   Writeln;
   Write(   'Pick a letter, any letter: ' );
   MenuChar := UpCase( ReadKey )
END; { MenuChar }


{$V-}    { Turn off string-parameter length checking }

BEGIN
   userQuits := False;
   REPEAT
      CASE MenuChar OF
         'A' : GetWord( 'Border foreground', WBForeColor, 0, 15 );
         'B' : GetWord( 'Border background', WBBackColor, 0, 15 );
         'C' : GetWord( 'Text foreground', WTForeColor, 0, 15 );
         'D' : GetWord( 'Text background', WTBackColor, 0, 15 );
         'E' : GetStr( 'Window title', WTitle, 40 );
         'Q' : userQuits := ChangesSaved( fileName, CBase,
                                 Ofs( CBase ), Ofs( EBase ) );
         'X' : userQuits := True
      END { case }
   UNTIL userQuits;
   GotoXY( 1, 25 )
END.
```

Listing 4: TCUNIT.PAS

```
(*
 *    PROGRAM : For editing typed constants in EXE files
 *    SYSTEM  : PC/MS-DOS / Turbo Pascal 4.0 or 5.0
 *    AUTHOR  : © 1988 by Tom Swan
 *)

UNIT TCUnit;


INTERFACE

USES  Crt;     { Standard Borland display unit }

PROCEDURE GetWord( prompt : String; VAR v : Word; low, high : Word );

PROCEDURE GetStr( prompt : String; VAR s : String; maxLen : Word );

FUNCTION ChangesSaved( fileName, searchStr : String;
   cbase, ebase : Word ) : Boolean;
```

4

```
IMPLEMENTATION


TYPE  ExeFile = File OF Char;     { Reads EXE files as file of char }


PROCEDURE GetWord( prompt : String; VAR v : Word; low, high : Word );

{ Prompt for word value, displaying prompt string and limiting
response in v to the range low..high. }

VAR   response : String[8];       { Holds response to prompt }
      newValue : Word;            { Possible new value for v }
      e : Integer;                { Error code for Val() }

BEGIN
   ClrScr;
   Writeln;
   Writeln( prompt, ' = ', v );
   Writeln;
   Writeln( 'Enter new value from ', low, ' to ', high );
   Write(   'or press Enter for no change: ' );
   Readln( response );
   IF Length( response ) > 0 THEN
   BEGIN
      Val( response, newValue, e );
      IF ( e = 0 ) AND ( low <= newValue ) AND ( newValue <= high )
       THEN
         v := newValue
       ELSE
         BEGIN
            Writeln;
            Write( 'Entry error.  Press Enter...' );
            Readln
         END { else }
   END { if }
END; { GetWord }


PROCEDURE GetStr( prompt : String; VAR s : String; maxLen : Word );

{ Prompt for string, displaying prompt string and limiting response
in s to string length 0..maxLen. }

VAR   response : String;       { Holds response to prompt }

BEGIN
   ClrScr;
   Writeln;
   Writeln( prompt, ' = ', s );
   Writeln;
   Writeln( 'Enter new string with up to ', maxLen, ' characters' );
   Write(   'or press Enter for no change: ' );
   Readln( response );
   IF Length( response ) > 0 THEN
   BEGIN
      IF Length( response ) <= maxLen
       THEN
         s := response
       ELSE
         BEGIN
            Writeln;
            Write( 'Entry error.  Press Enter...' );
            Readln
         END { else }
   END { if }
END; { GetStr }
```

Code continues . . .

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Swan Code, Continued

5

```
PROCEDURE ShowError( e : Integer );

{ Display an error message.  e>0 = I/O error; e<0 = other error }

BEGIN
   IF e > 0
      THEN Writeln( 'I/O Error #', e )
      ELSE Writeln( 'Error in EXE file format' );
   Writeln;
   Writeln( 'WARNING: EXE file may be damaged!' );
   Writeln;
   Write( 'Press Enter...' );
   Readln
END; { ShowError }


{$i-}    { Shut off I/O error checks }


FUNCTION FoundCBase( VAR f : ExeFile; VAR searchStr : String;
   VAR offset : LongInt ) : Boolean;

{ Return True if searchString (CBase) is found in file f.  If found,
then return byte offset to string in file. }

VAR   position : LongInt;        { Possible position of match }
      ch : Char;                 { Holds candidate bytes from file }

   FUNCTION FoundMatch : Boolean;
   { True if current position = search string }
   VAR   i : Integer;   { searchStr index }
   BEGIN
      FOR i := 2 TO Length( searchStr ) DO
      BEGIN
         Read( f, ch );
         IF ch <> searchStr[i] THEN
         BEGIN
            FoundMatch := False;
            Exit
         END { if }
      END; { for }
      FoundMatch := True
   END; { FoundMatch }

BEGIN
   Reset( f );              { Start search at beginning of file }
   WHILE NOT Eof( f ) DO
   BEGIN
      Read( f, ch );
      IF ch = searchStr[1] THEN        { Test one char }
      BEGIN
         position := FilePos( f );     { Remember position }
         IF FoundMatch THEN            { Check for match }
         BEGIN
            offset := position - 2;    { Found: return offset }
            (* Writeln; Writeln( 'Offset = ', offset ); *)
            FoundCBase := True;        { Set function result }
            Exit                       { Stop searching }
         END ELSE
            Seek( f, position )        { Continue search }
      END { if }
   END; { while }
   FoundCBase := False     { searchStr isn't there }
END; { FoundCBase }
```

6

```
PROCEDURE SaveData( VAR f : ExeFile; offset, cbase, len : LongInt;
  VAR e : Integer );

{ Write len bytes to file f, beginning at byte #offset in the file
and transferring from memory len bytes starting at DS:cbase.  Return
any errors in e.  This copies the in-memory typed constants to the
EXE file image on disk. }

VAR   i : Word;       { Mem[] array index }

BEGIN
   Seek( f, offset );
   FOR i := 0 TO ( len - 1 ) DO
   BEGIN
      Write( f, Char( Mem[ DSeg:( cbase + i ) ] ) );
      e := IoResult;
      IF e <> 0 THEN Exit
   END { for }
END; { SaveData }


FUNCTION ChangesSaved( fileName, searchStr : String; cbase,
   ebase : Word ) : Boolean;

{ Return True if typed constants in memory are written to disk.
fileName must be a Turbo Pascal compiled EXE file.  searchStr
should equal the CBase marker string at the start of the typed
constants area.  cbase should be the in-memory offset to the CBase
typed constant.  ebase should be the in-memory offset to the EBase
typed constant. }

VAR   f : ExeFile;          { Read .EXE as a char file }
      offset : LongInt;     { Byte offset to CBase in .EXE file }
      err : Integer;        { Error code }

BEGIN
   GotoXY( 1, 25 );
   ClrEol;
   Write( 'Saving changes to ', fileName, '. Please wait...' );
   Assign( f, fileName );
   Reset( f );
   err := IoResult;
   IF err = 0 THEN
      IF FoundCBase( f, searchStr, offset )
         THEN SaveData( f, offset, cbase, ( ebase - cbase ), err );
   ChangesSaved := ( err = 0 );  { i.e. True if no error }
   Writeln;
   IF err = 0
      THEN Writeln( 'Changes saved' )
      ELSE ShowError( err );
   Close( f )
END; { ChangesSaved }


END. { TCUnit }
```

♦

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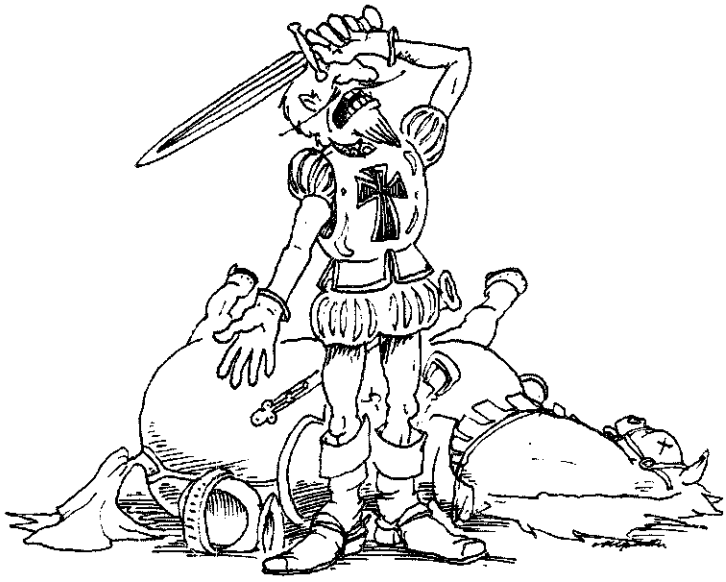
My Kingdom for an Overlay!

by
Bill Madison



The ability to overlay large applications is taken for granted by most modern software developers. Thus, the users of Borland International's Turbo Pascal were quite shocked to discover that a built-in overlay capability present in Release 3 was missing from Release 4.

The trauma induced by this lack was alleviated when TurboPower Software provided an overlay package. Using a post-processor, the software processed a TP4 .EXE file into a new .EXE file plus an .OVR file. The total cure came with the advent of Turbo Pascal Release 5—Borland's reintroduction of an embedded overlay capability.

Not surprisingly, the program designer must use entirely different setup procedures when using the TurboPower Software system versus the Borland system. How do the two schemes compare? What application design and implementation questions must be resolved in using each system?

Ultimately, these issues resolve into a single question: "Shall I stick with TP4 or upgrade to TP5 for both current and future work?" TurboPower Software's overlay manager cannot work with TP5 except under very restrictive circumstances. Further, I have been informed that no current plans exist to port the TurboPower product over to TP5 and place it in competition with the Borland overlay manager.

I have had an excellent opportunity to examine this question, since I am currently working on two quite different overlaid applications. One is my Shareware product, ReadyRef. ReadyRef is an overlaid TSR, primarily I/O bound. Thus, the overriding design problem (and the only reason for using overlays) is keeping resident portion size as small as possible consistent with reasonable response time.

The other application—a large, very complex transportation simulation package—is heavily compute bound, written for a client. The primary concern here is minimizing overlay thrashing, which enhances product maintainability.

Both products have evolved from a rather simple, nonoverlaid design into an overlaid application as new features have been incorporated. Thus, I have been able to examine problems associated with:

- Conversion of a nonoverlaid application to an overlaid application using the TurboPower Software overlay manager (ReadyRef)
- Conversion of an application using the TurboPower Software overlay manager to one using the Borland overlay manager (ReadyRef again)
- Conversion of a nonoverlaid application to an overlaid application using the Borland overlay manager (the simulation product)

The remainder of this article compares the structure and operation of these two overlay managers. For simplicity's (and brevity's) sake, let's agree to refer to TurboPower Software as "TPS," and Borland International as "BI."

Structure and Operation of the Overlay Managers

Both the TPS and the BI overlay managers have unit-level granularity. This is unlike the overlay manager embedded in TP3, which had a granularity at the block (i.e., procedure or function) level. No particular problem arises as long as you stay aware of this. Also in contrast with the TP3 system, both the TPS and the BI systems produce only a single overlay file (with an extension of .OVR), which contains all of the overlaid units.

With this much said, however, any similarity between the two ends. In the following section, I will describe various differing attributes of both systems in parallel and score each (in my usual impeccably objective manner) on a scale of 1 to 5 (1 = low).

What Can and Cannot Be Overlaid, and Other Cautionary Notes

The following should not be overlaid within TPS:

- The OVERMGR (overlay manager) unit itself (aren't you surprised?)
- Units containing interrupt handlers
- Units with routines called directly or indirectly via procedure pointers

Additionally, care must be taken when passing code segment–based constants as actual parameters if the caller and the block being called are in different units that share the same overlay group. (An *overlay group*, a concept unique to the

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TPS system, is a designer-designated collection of units that share the same space in the overlay buffer. There can be many overlay groups in a single application.)

The problem with code segment–based constants is circumvented easily by forcing the argument onto the stack before calling the target block, as in the following example:

Assume that unit X contains procedure X1 and uses unit Y. Further assume that unit Y contains procedure Y1, and that both units share the same overlay group. Finally, assume that procedure Y1 takes two VALUE parameters, S : String and I : Integer.

Then, if procedure X1 contains the following statements, erroneous results will occur:

```
const I = 100;
...
Y1('Hi, there!', I);
...
```

The problem may be easily remedied by changing the call to force the parameters onto the stack. This can be accomplished (take my word for it) by placing the constants in expressions that must be evaluated immediately prior to transferring control to the target block:

```
: const I = 100;
...
Y1('Hi,there!'+'', I+0);
...
```

The following should not be overlaid within BI:

- The OVERLAY (overlay manager) unit itself
- Units containing interrupt handlers
- Units not compiled with the $O+ compiler directive

Score: TPS - 2, BI - 5

How Many Can Be Overlaid?

As delivered, the TPS system can support up to six overlay groups, each of which can contain a maximum of 51 units. The entire program can also have a maximum of 51 overlaid units. Of course, additional nonoverlaid units can be used, but the total (overlaid + nonoverlaid) cannot exceed 255 units.

These limits can be changed easily; required steps are well documented. Two constants must be changed in an Include file, and identically named constants must be changed in an .ASM file. The .ASM file must then be assembled to an .OBJ file. Finally, both the OVRMGR unit and the OVERLAY program must be rebuilt. Additionally, the application to be overlaid must first be compiled to a vanilla-flavored .EXE file and then post-processed into the final .EXE and .OVR files. The total size of the application is limited by the maximum-size .EXE file that TP4 can produce (approximately 1 megabyte).

No limitations are stated in the BI documentation.

Score: TPS - 4, BI - 5

Designing the Overlay Structure

Within TPS, specifying the overlay structure requires only the creation of one text file (with an .OSP extension) in addition to the normal program files. This file contains—on each line—the name of a unit to be overlaid and the designation of the overlay group into which it is to be placed.

Only one program change is required to use the overlay system. This is the addition of the OverMgr unit at the head of the Uses clause in the main program.

The decision as to which units to overlay must be determined on the basis of the programmer's knowledge of the application. No deterministic algorithm is provided.

A similar decision is required for assignment of an overlay group. However, some aids are available to make the job a good deal easier than pure hit or miss.

First, when compiling the program, it is necessary to create a .TPM file and convert it to a .MAP file (by running the TpMap program). The .MAP file, in conjunction with the .OSP file, is used as input to the OVERLAY program to create the new .EXE and .OVR files.

The existence of a .MAP file correctly reflecting the sizes of the units making up the program is additionally useful. The file directs the designer's attention to those units that might benefit from redesign or fragmentation.

Second, the creation of the final .EXE and .OVR files is the result of execution of the post-processor OVERLAY program against the original .EXE file. Thus, you can try a new overlay structure without recompiling the application: Just modify the .OSP file and rerun the post-processor.

Considering both factors, what could be a seat-of-the-pants guessing game can become a series of controlled experiments. To my mind, this is one of the most significant advantages of the TPS system.

Several steps are required in using the BI overlay system:

1. All units used by the application must be mentioned in the Uses clause of the main program. (I find this a definite minus vis-à-vis program readability. I strongly prefer to mention those units actually used by a program or unit.)
2. The source file for the main program must be edited to include the Overlay unit in its Uses clause, ahead of the first unit to be overlaid.

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3. This source file must be further edited by including a {$O <unitname>} compiler directive for each unit to be overlaid.
4. All units that are to be overlaid must be compiled with the $O+ compiler directive. (The effect on code size here seems to be negligible, adding only one or two paragraphs at most to the size of the .TPU file. The largest effect I have seen is ten paragraphs for a general utility unit of mine that contained several dozen blocks.)
5. All blocks that directly or indirectly call a block in an overlaid unit must be compiled using a FAR call. In effect, this means that every unit and the main program had better be compiled with the $F+ compiler directive. The only exception is nonoverlaid units that are completely self-contained.

Score: TPS - 5, BI - 2

Overlay System Initialization

Under normal conditions, overlay-system initialization occurs automatically in TPS and need not concern the programmer. The primary exception to this occurs when writing TSRs. In this case, a call to the procedure SetOverlayHandler should occur each time the TSR is activated. (There are certain other processes not directly concerning the overlay system—but affecting it—that should be performed at the same time. These are well documented.)

Initialization of the overlay system in BI, except under certain rather sterile (for me) conditions, represents an esoteric combination of diabolism and voodoo. The TP5 Reference Guide stresses the importance of including the Overlay unit in the Uses clause of the main program, ahead of the first overlaid unit. The guide also mentions the need to force initialization of the overlay unit prior to execution of any code (including initialization code) for any overlaid unit. This may mean that the calls to OvrInit, OvrSetBuf, and OvrInitEMS must be placed in the initialization section of a separate, nonoverlaid unit. In addition, the calls must appear in the Uses clause of the main program, ahead of the mention of the first overlaid unit.

Nowhere in the guide could I find (and it took me four transcontinental phone calls to BI to discover) that the same rules apply when any unit—overlaid or not—contains initialization code that manipulates the heap in any way. Again, overlay-system initialization must precede execution of the heap-diddling initialization code of the guilty unit. This can be frustrating particularly when you do not have access to a unit's source code. How do you know?

The TP5 Reference Manual is, in my humble opinion, downright misleading in this regard. In the discussion of the OvrSetBuf procedure (pp. 344ff) is the statement: "OvrSetBuf requires that the heap be empty;. . . make sure to call OvrSetBuf before the Graph unit's InitGraph procedure. . . ." I find it difficult to determine how a reasonable person (among this collection I clearly include myself) could infer from that statement that the Graph unit includes heap-diddling initialization code.

Score: TPS - 5, BI - 2

Use of EMS

The TPS overlay system automatically uses EMS (Lotus/Intel/Microsoft Expanded Memory Specification) memory if it is available. To prohibit the use of EMS, change one constant in a defined "user patch area," and recompile the overlay manager unit. Alternatively, you may use an installation program to set this and other constants. (Source is provided for this installation program to customize it for a particular application.)

Since the EMS usage decision is made at execution time rather than at link time, all of the code relating to EMS will remain in the .EXE file. Should you need to reduce to a minimum the nonoverlaid portion size of the application, you must excise the EMS-related code from three files: the .PAS files for the overlay manager unit and the overlay post-processor, and the .ASM file common to both. All of the code is extremely well commented, however, making such an excision quite straightforward. (It worked for me on the first try—truly remarkable considering my fat fingers and the not-always-crystal clarity of my mental processes.)

Use or nonuse of EMS within the BI system is a model of simplicity. Following the initialization of the overlay system, but prior to any other function, a call to the procedure OvrInitEMS causes the overlay system to use EMS if it is present. If it is not present, the overlays will be loaded from disk as required.

Score: TPS - 3, BI - 5

Thrashing

The TPS system has retained the functionality of the TP3 separate overlay files by permitting the user to define separate "overlay groups." Blocks within one overlay group can call blocks within another overlay group without causing thrashing.

The default state of the BI system will not allow thrashing to occur if the sum of the sizes of the units involved is less than the size of the largest unit being overlaid. If this condition is not met, thrashing will occur. However, the BI system provides a mechanism for overcoming this problem by using the procedure OvrSetBuf. This procedure accepts a single-value parameter, which is the new size for the overlay buffer. If the buffer size is set at the size required by the maximum sum of the sizes of all units (which must be co-resident in order to satisfy stacked block calls), then unnecessary thrashing will be eliminated.

The BI system does make it difficult to determine just what this number is to be. Perhaps the simplest way to explain this problem is by contrasting the two systems.

The TPS system creates the .OVR file using a post-processor program that operates on the compiler-generated .EXE file. When you generate a .MAP file as part of the compilation, the exact RAM-based size of each unit can be determined. (Aside from any other benefits, this procedure provides an excellent development aid: It points to those units that can be fragmented to reduce materially the application's RAM requirements.) The TPS system then automatically sets the size of the overlay buffer to accommodate the largest unit within the defined overlay groups.

In contrast, the BI system produces both the .EXE and the .OVR files as direct output from the compiler. Therefore, any .MAP file produced will display only a small residuum for each overlaid unit (typically less than 100h bytes.) I have found absolutely no clue as to the actual RAM requirements of an overlaid unit.

Score: TPS - 5, BI - 2

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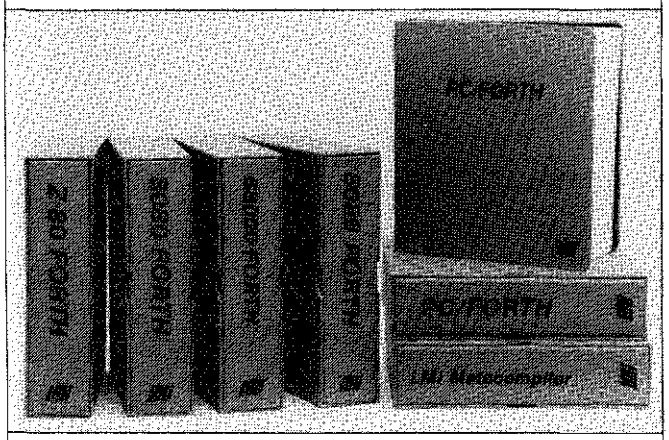

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Summary and Conclusions

Weighing the scores equally for the five system attributes examined above results in the following average scores:

ATTRIBUTE	TPS	BI
What can be overlaid:	2	5
How many can be overlaid:	4	5
Application design:	5	2
Initialization:	5	2
Use of EMS:	3	5
Thrashing:	5	2
Average scores:	4.0	3.5

However, I don't consider these attributes to be equal. Instead, I would weigh application design most heavily, followed by initialization. I would then assign median weight to what can be overlaid and use of EMS. Finally, I would assign thrashing a lower-than-average weight. Assessing the scores with these new factors provides the following results:

ATTRIBUTE	W	TPS	BI
What can be overlaid:	2	2 4	5 10
How many can be overlaid:	1	4 4	5 5
Application design:	4	5 20	2 8
Initialization:	3	5 15	2 6
Use of EMS:	2	3 6	5 10
Thrashing:	1	5 5	2 2
Sum of Weights:	13		
Average scores:		4.2	3.2

Assign weights as you will. At least you should now have some basis for judgment.

Last, but certainly not least, we should consider the importance of TP5's other features that are not available in TP4. While not easily quantifiable, certainly the value of these features must be weighed in making the final program selection. This factor must be given even greater weight when designing new applications than when converting applications that have been developed and are operational under TP4, as mine were.

Considering all factors, however, I would tend to use the TPS overlay system for any TSR application. For general applications, I would let the importance of the TP5 compiler features dictate which overlay system to use.

Finally, in that "best of all possible worlds," programmers everywhere would produce a ground swell of phone calls to TurboPower Software convincing them that a viable market exists for two different overlay systems in a TP5 environment. But then, we can't have everything, can we? ♦

Bill Madison is an independent computer consultant whose clients include Amtrak, the National Institutes of Health, the National Oceanic and Atmospheric Administration, the National Weather Service, the U.S. Department of Health and Human Services, and R.J. Reynolds Tobacco Co. Bill has been a member for nine years, and a chairman for seven years, of ANSI/X3/SPARC, the staff planning committee for the group within ANSI responsible for the development of industry standards relating to information systems. Readers may contact Bill at W.G. Madison and Associates, Ltd., P.O. Box 898, Greenbelt, MD 20770, 301-552-7234 (CompuServe 73240,342).

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From Pascal to Modula-2

The TopSpeed Modula-2 Environment

by
John J. Newlin

Dr. Niklaus Wirth, the father of Pascal, formed a project team in 1977 to design a modern computer system. One product of this development was a new programming language, now known as Modula-2. Quite naturally, Modula-2 is a strongly typed language that contains many similarities to Pascal. In creating Modula-2, Dr. Wirth greatly extended the support for structured, modular programming that he had built into Pascal.

Pascal was slow to gain acceptance as a serious programming language until the success of Borland's Turbo Pascal. I was one of the early purchasers of Turbo Pascal. Its compiler technology was so impressive that I asked a technical-support person at Borland if the company had plans to produce a Modula-2 compiler. Borland answered affirmatively, and, as many Turbo buffs know, rumors of a Turbo Modula have abounded for the past several years.

Indeed, such a project was in the works at Borland. In 1987 Niels Jensen, a founder of Borland, and two former Borland programmers formed a spinoff company called Jensen and Partners International (JPI). JPI then purchased the rights to the partially completed Modula-2 compiler and the code-generation technology that the partners had developed while at Borland. That compiler is now a finished product, currently marketed by JPI as TopSpeed Modula-2.

Right out of the box, TopSpeed Modula-2 is a polished, attractive product. The compiler files are delivered on three 5.25" diskettes (3.5" diskettes are available) that include system, library object, and library source. Score one for JPI for delivering the library source at no extra charge! System documentation is comprised of two manuals: a user's manual and a language tutorial.

The JPI Modula-2 package is *not* for novice programmers. Although the documentation is excellent, it is lean and mean, directed more toward programmers familiar with separate compilation and linking. I see the package as ideally suited to producers of serious programs with Borland's Turbo Pascal 4.0/5.0 or Turbo C. Experienced C programmers would probably make the transition to TopSpeed Modula-2 as easily as they would to Turbo Pascal.

The user's manual is divided about equally between explaining operation of the integrated environment and defining the TopSpeed language, compiler, and supporting libraries. Even with the numerous code examples throughout the manual, it's still lean and mean. The indexing is fairly complete, but when I tried to find an explanation and example of aliasing, the index pointed me to the alias compiler directive switch. A thorough search of the manual failed to locate any more than a couple of hints about invoking this important feature (important because of the strict syntax requirements of Modula-2). I called JPI and learned that any defined entity may be aliased by placing a statement in the CONST section of the importing module as follows:

```
CONST              Alloc ::= Storage.Allocate;
```

The double-colon–equal sign symbol combination directs the compiler to equate Alloc with a call to Storage.Allocate. Thus, using aliases can save a lot of laborious typing.

Another weakness of the manual is its incomplete listing of TopSpeed's various additional extensions to Modula-2. In some cases, the manual explains that a specific entity is an extension, but most users concerned about portability are going to need a list of the TopSpeed deviations from Wirth's current standard. JPI informs me that it plans to correct this in the next manual upgrade.

The manual's strength lies in its support for users who are not familiar with Modula-2. Chapter 2, titled "Case Studies," presents a number of code examples that begin with the classic "Hello World" program and become progressively more complex. The examples and accompanying explanations are designed to make the user increasingly familiar with the elements of Modula-2 as implemented in the TopSpeed system. This chapter is not a tutorial, however. K. N. King's *Language Tutorial* manual is provided for that purpose. Many compiler packages include third-party tutorials, but these are usually general-language tutorials not specifically related to a particular compiler. In this case, Mr. King's work is pointed specifically at the TopSpeed system. That's a real plus and another score for JPI.

The TopSpeed's system foundation is a multiwindow, integrated programming environment similar to that implemented in Turbo Pascal 4.0/5.0. It's slick, it's fast, and it's functional. Modula-2 programs can be created, compiled, linked, and executed without leaving the environment. In addition, the extensive tree of pop-up windows and menus provides complete knowledge and control of the system. The advantage of Modula-2 programming lies in the design and coding of individual, separately compiled modules. Maximum support for the methodology is provided by the TopSpeed environment. The heart of the integrated environment is the editor—and what a great editor it is! Four separate editing

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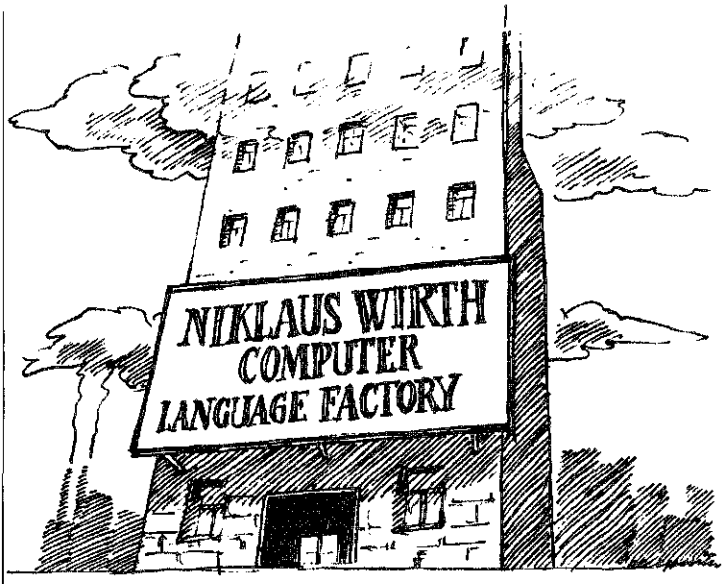

windows are available for editing four different files simultaneously. Switching between the editing windows is accomplished with a single, lightning-fast keystroke. Not only is multifile editing provided, but these are virtual editors that permit accessing a file up to one-half megabyte in size! It's also possible to use the separate editing windows to view four different parts of the same source file. Changes made through one window are automatically inserted in the other three. Now that's source editing power!

But that's not all, by a long shot. You can configure TopSpeed's integrated environment to your liking. If you don't like the placement, the size, or the colors of a particular menu or window, you can change it. All of the editor functions, including commands and key assignments, can be customized readily to suit your tastes. I say readily customized, because TopSpeed has taken a somewhat different approach to configuring the environment than that used in other systems. Instead of a stand-alone installation or configuration program, ASCII definition files are provided that can be modified quickly and easily from the editor.

In my opinion, the only additional feature needed to enhance the editor is a macro-definition capability. For you to understand this capability's importance, I must digress briefly to Modula-2 syntax. Creating Modula-2 source code tends to be a bit clumsy and keystroke intensive. There are two reasons for this. The first is that Modula-2 syntax is case sensitive. A variable named Count is treated as separate from one named COUnt. Additionally, all reserved words must be entered in caps. The second reason is related to Modula-2 qualifiers. If you import an entire module, (for example, IMPORT MyModule;), then you must reference every entity in that module with a qualifier. For example, suppose MyModule contains a procedure named MyProc. The programmer is required to reference this procedure as MyModule.MyProc. That's a lot of typing that the inclusion of a macro facility could alleviate. I'm not advocating complete context-sensitive automation, just the ability to define and invoke string macros. TopSpeed *does* include helpful editor commands that will change a cursor-designated word to all caps as well as change the case of a word to that of the first occurrence of the word in the file. Compiling and linking a program from the editor is fast and easy. You can invoke the compiler either through the pop-up menu system or by pressing Alt-C. Alt-R will compile and run the program in memory, and Alt-L invokes the Linker. JPI's advertised compiler speed of 4000–6000 (8MHz AT) lines per minute is not in the Turbo 5.0 class, but it's fast enough not to cause significant delay in program development. Unlike Turbo 4.0/5.0, no option exists to keep the linker in memory with the compiler. Also unlike Turbo, the linker is a truly "smart" linker. Turbo will import all the code of an assembled module, even though some of the assembly procedures are not referenced. The TopSpeed linker only imports those entities—types, constants, variables, procedures, and so on—that are referenced by the importing module, whether compiled or assembled. JPI provides what I think is a very nice compiler feature. Instead of ceasing compilation at the first error discovered, the TopSpeed compiler continues to the end of the source file or until 50 errors have been discovered and reported. At the end of the compilation, a separate error-editor window is presented to the programmer, with the cursor positioned on the first error. With a single keystroke, the programmer can then immediately move to each subsequent error, correct it, and move on to the next. The standard system does not contain an integrated debugger, but JPI offers a stand-alone debugger, called the Visual Interactive Debugger, or VID. Unfortunately, I haven't had the time to exercise VID, but it appears to be a very powerful development tool. Another very helpful feature is the automatic MAKE facility resident in the compiler. Module dependencies are automatically calculated, and out-of-date modules are recompiled. For example, if a definition file is changed, the automatic MAKE facility will ensure that all modules importing the altered definition will be compiled. A manual MAKE may be invoked from a menu; a complete module-by-module BUILD facility is also available.

JPI not only provides a complete set of library modules with the compiler but provides the source code as well. That's a big plus as far as I'm concerned. The TopSpeed library contains the following 13 modules:

```
SYSTEM          Lib          FIO          ProcTrace
AsmLib          Storage      IO
MATHLIB         Process      Window
Str             Graph        FloatExec
```

Modula-2 programmers will recognize most of these as standard library modules, but one nonstandard module deserves special mention. I know of no other basic compiler package that includes a complete windowing facility. The programmer usually has to use third-party support to obtain high-level window routines or write his own. TopSpeed's Window module is a powerful window-management system that allows the programmer to create, stack, move, change, and write to various windows.

The *tour de force* of Modula-2 is, in my opinion, its intrinsic support for creating multitasking programs. Standard Modula-2 routines such as NEWPROCESS, TRANSFER,

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and IOTRANSFER reside in the SYSTEM module per language convention. But to accomplish true multitasking (time slicing on a single CPU), the programmer must utilize a scheduler to manage the coroutines. TopSpeed provides just such a scheduler in the Process module. The procedures contained in this module comprise a powerful set of tools for creating and managing coprocesses. Processes can communicate through shared global variables or via signals. Signals are used as a means of process synchronization. JPI provides a rich assortment of compiler directives, giving the programmer full control of the compilation and linking process. For example, there is a directive that controls which 80x86 registers will be preserved during a procedure call. Another directive enables or disables the C language calling convention for procedures to permit the linking of C object code (TopSpeed uses standard .OBJ file format). The programmer can even designate, by name, in which data segment to place the global variables declared in a module and in which code segment to place the code. There is, however, no control over data alignment within records. By default, record field data is byte aligned, and that cannot be changed.

Excellent heap-management tools are provided in this compiler. In addition to the standard Modula-2 ALLOCATE and DEALLOCATE procedures, TopSpeed includes the capability to create and manage separate heaps. The programmer can create new heaps, change their sizes, and deallocate them. Part of this convention permits the assignment of the new heap to a specific base segment. The standard heap-allocation procedures return a segmented address for this purpose. Pascal programmers will appreciate the inclusion of language extensions, such as NEW and DISPOSE, as predefined procedures.

I have neither the space nor the time to touch on all the features that are packed into the compiler. In my opinion, a compiler should be judged on two main criteria: First, is the system user friendly—meaning does the design and implementation of the user interface enhance the programmer's efficiency? I feel that Modula-2 is one of the very best in this test. It doesn't get in your way, yet the system is sophisticated and powerful enough to support production of large, complex projects.

The second criteria is, of course, the quality of the code produced. The following benchmark tables address that issue:

SIEVE BENCHMARK

ITERATIONS	TP4	TP5	JPI
25	6.37	6.4	2.41
50	12.74	2.96	4.88
EXE FILE SIZE	1504	1440	1700

ACKERMAN BENCHMARK

INPUT VALUES	TP4	T5	JPI
(3,6)	2.2	2.26	1.98
(3,7)	9.17	9.17	7.27
EXE FILE SIZE	1456	1392	1691

These figures were derived using an AST Premium/286 running at 8 MHz. The programs were run in memory with range and error checking disabled. In each case, compilation to the disk .EXE file was effected after removing all timing and output code. Don't ask me to explain why the TP5 figures are not much better than those produced by TP4. I double-checked the code and environment and ran the programs 20 times each, with the same results. You can see from the tables that the speed of the code produced by the JPI TopSpeed compiler and linker is superior to that of Turbo 4.0/5.0. I attribute the difference in .EXE file sizes between TopSpeed and Turbo to TopSpeed's automatically importing its SYSTEM module whether it is declared or not. I did not have the time to construct and run any floating point benchmarks, but results of other such tests suggest that TopSpeed retains its superiority.

I was surprised to find that this compiler does not support in-line code. When queried about that, a JPI representative explained that in-line assembly language would compromise the compiler's optimization techniques. Considering the speed of the compiled code and the ability to link separately-assembled modules, in-line code support is really not a problem with this compiler. I feel that the inclusion of such language extensions as absolute variables, string handling, heap and quick sorting, port access, and DOS service access to be much more important. TopSpeed has all of these and more. For $59.95, JPI offers an add-on package they call the "TechKit." The TechKit includes a high-speed assembler and several additional Modula-2 modules. The assembler is designed specifically to support the TopSpeed Modula-2 development environment and in that regard supports import and export of entities to and from compiled modules. Library modules included in the TechKit are TSR, RS, BIOSIO, Int24, and LIM. These module names provide obvious clues to the nature of their functions: TSR provides memory resident support, RS contains asynchronous communications routines, BIOSIO extends keyboard interface support, Int24 is a critical error handler, and LIM offers several basic EMS (expanded memory) procedures. Earlier in this review, I mentioned two primary criteria on which to judge compiler systems. Based upon these criteria, I judge the TopSpeed Modula-2 compiler as an outstanding software development system. The TopSpeed integrated environment is friendly, a pleasure to use, and features the best source code editor one could hope to find. In addition, TopSpeed compiled code is extremely tight and fast. As a software developer who spends a lot of time one-on-one with a compiler, I am seriously considering making TopSpeed my primary development system. I highly recommend it. ♦

John J. Newlin is a retired naval aviator who works for Hughes Aircraft Co. as a systems engineer. John holds degrees in mathematics and computer science and has programmed extensively in assembly, Turbo Pascal, Marshal Pascal, and Modula-2. He is the author of SCOUT, a memory-resident disk/file/directory manager, and ARCMASTER, a "point-and-shoot"-style interface between the user and ARC and de-ARC programs. John is a charter member of the Association of Shareware Professionals. Readers may write to John at the following address: John J. Newlin, 6198 Agee St. #71, San Diego, CA 92122.

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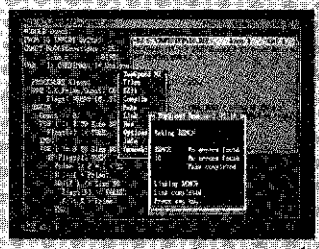

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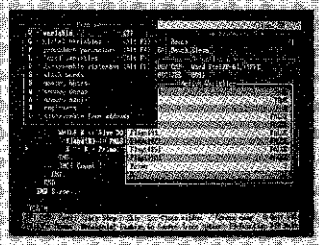

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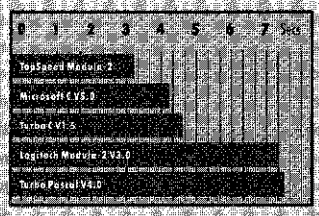

Steve benchmark measured by the British Standards Institution (BSI) — 25 iterations on an 8MHz AT.

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Which Code Is Faster?

by
Ethan Winer

No matter what the language, we all strive to create programs that execute in the least amount of time while using the fewest number of bytes. Unfortunately, many programmers who use a high-level language have no way to determine which statements are the most efficient.

The purpose of this article is twofold. We will discuss various BASIC statements to see which ones are faster and smaller. Then we will examine the actual machine instructions generated by QuickBASIC 4 and compare them with the original BASIC source code.

Besides seeing first hand how a compiler operates, we'll also learn about Microsoft's excellent CodeView debugger in the process. CodeView is included with a number of Microsoft languages, including BASCOM 6 and current versions of the macro assembler.

All of the code examples presented here will be shown for stand-alone BASIC programs that do not require BRUN runtime library support. Also, integer variables will be used exclusively. Most programmers use integers whenever possible, and this will prevent the examples from being obscured by floating point math operations.

String Operations

String operations in a QuickBASIC program consist of many calls to routines contained in the BCOMxx.LIB library file. This makes them extremely convoluted and, thus, difficult to trace through. However, manipulating strings efficiently in BASIC is often more a matter of common sense than anything else.

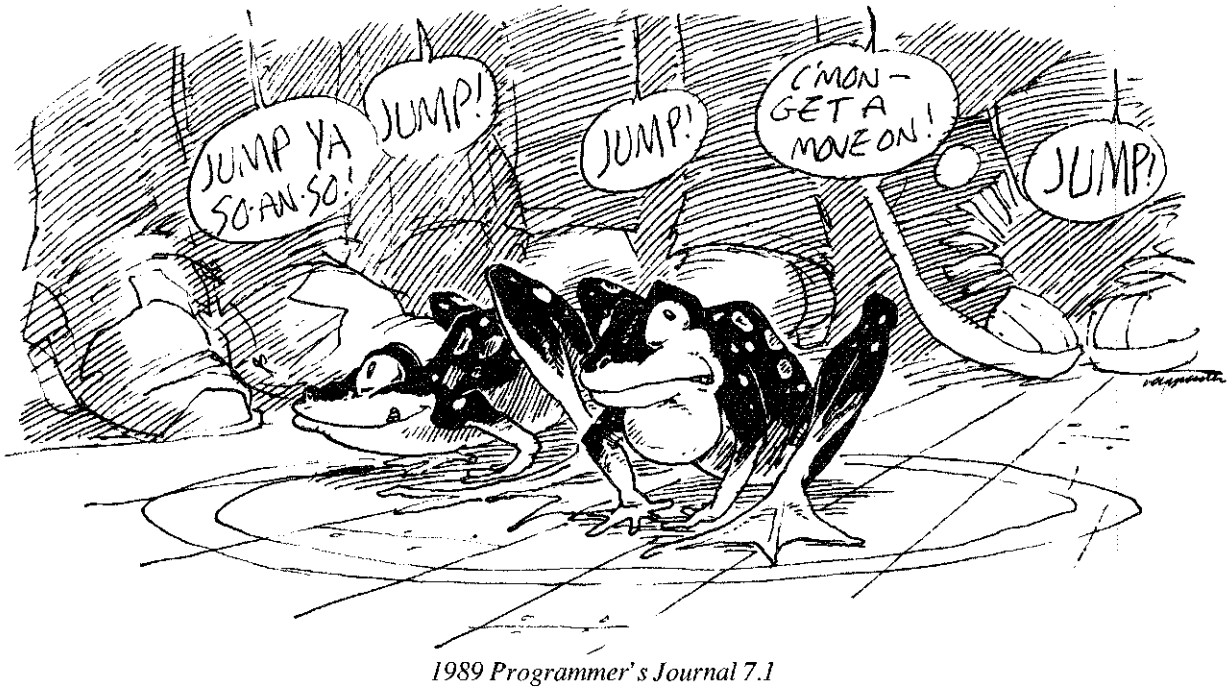
Unlike most other high-level languages, BASIC allows strings to have varying lengths. Whereas languages such as Pascal and C require you to declare all strings and their lengths ahead of time, BASIC is much more forgiving. Of course, nothing comes for free, and so it is with strings in BASIC.

Every time a string is assigned or reassigned, a new memory location is used to hold the contents. Even if the new string is the same length as or shorter than it had been previously, BASIC abandons the memory it occupied and allocates a new space in "near" memory. Near memory is where all nonarray variables are stored; it is limited to 64K.

Because finding a new place to store a string takes time, this is one of the most inefficient operations BASIC does. Therefore, for our first example we'll look at two very different ways to build a string.

Let's say you intend to read a line of characters from the display screen and store them into a string. One method would be to append new characters in a loop like this:

```
S$ = ""                 'clear S$
FOR X = 1 TO 80         'read the top line
    S$ = S$ + CHR$(SCREEN(1, X))    'build the
                                     string
NEXT
```



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Besides being slow because new memory must be found for each new version of S$, this method leaves 3240 bytes of memory abandoned by the preceding assignments. Of course, BASIC will eventually reclaim this memory, but that takes even more time. Because BASIC leaves old string data lying around as it works, it must reorganize its string space from time to time. This process is called *garbage collection.*

Understand that variable-length strings are not a bad thing. Indeed, this is just one of the many advantages BASIC has over less capable languages like C and Pascal.

LSET, RSET, and MID$

BASIC provides two other ways to assign characters to a string—LSET and RSET, and the statement form of MID$. Where the example above must constantly assign a new string for each character that is appended, LSET, RSET, and MID$ let you insert characters into an existing string. Thus, a single string of the correct length may be assigned only once, and the new characters will be placed into subsequent locations.

Using MID$ makes the most sense for a screen-reading routine. It would be coded like this:

```
S$ = SPACE$(80)     'set aside 80 characters
                     in S$
FOR X = 1 TO 80     'read the top line
    MID$(S$, X, 1) = CHR$(SCREEN(1, X))
                    'insert each character
NEXT
```

In a test where 5000 characters were inserted, MID$ filled the string in only 1.2 seconds, as opposed to 7 seconds for the first example.

LSET and RSET also replace characters in an existing string; however, they also clear all characters that are not being replaced:

```
X$ = "Testing 1, 2, 3"
LSET X$ = "Hi"        'now X$ = "Hi          "
RSET X$ = "Lo"        'now X$ = "         Lo"
```

As you can see, LSET left-justifies the string being inserted, and RSET right-justifies it.

Another important way to speed up string operations is to use their ASCII values whenever possible. For example, suppose you need to search through a string array for a particular item. One common method would be:

```
FOR X = 1 TO ArraySize
    IF Array$(X) = Search$ THEN
       PRINT "Found at element"; X
       EXIT FOR
    END IF
NEXT
```

A better approach would be to determine the ASCII value of the string being searched for and compare that to the value in the array:

```
A = ASC(Search$)
FOR X = 1 TO ArraySize
    IF ASC(Array$(X)) = A THEN
       IF Array$(X) = Search$ THEN
          PRINT "Found at element"; X
          EXIT FOR
       END IF
    END IF
NEXT
```

Though this takes a bit more effort to code, the resulting improvement can be substantial. Because BASIC operates on integers much more quickly than it can on strings, a lot of unnecessary testing at the string level will be avoided.

There are certainly other, similar, ways in which you can increase the string performance of a program. As I said earlier, many solutions present themselves once you understand how BASIC operates. On that note, let's take a look inside QuickBASIC to see some of the ways in which your source code is translated into executable machine instructions.

Variable Assignments

Imagine that you are writing a program and that at some point several variables must be assigned to the same value. One way would be to assign the value repeatedly, as shown below:

```
A = 13
B = 13
C = 13
D = 13
E = 13
```

Another possibility is to assign the first variable from a constant and the remaining variables from the first one:

```
A = 13
B = A
C = A
D = A
E = A
```

The second example is much more efficient, but let's see why.

When QuickBASIC compiles your source program, it assigns and remembers an address for each variable it encounters. This lets it replace references to those variables with addresses that the PC's processor can understand. Consider the following assignment statement:

```
A = 13
```

This is compiled to the following machine and assembler instructions:

```
C70636000D00        MOV WORD PTR [0036], 13
```

As you can see, QuickBASIC has placed the variable A at the absolute address 36, and a six-byte assembler instruction is

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required to assign it. (The bytes of machine language that QuickBASIC generates are shown to the left of the equivalent assembler mnemonics.) Two bytes are used for the actual instruction, another two to specify the address (0036), and two more for the value 13.

Thus, QuickBASIC will code the first example like this:

```
A = 13     C70636000D00    MOV WORD PTR [0036], 13
B = 13     C70638000D00    MOV WORD PTR [0038], 13
C = 13     C7063A000D00    MOV WORD PTR [003A], 13
D = 13     C7063C000D00    MOV WORD PTR [003C], 13
E = 13     C7063E000D00    MOV WORD PTR [003E], 13
```

Notice that two-byte memory addresses and values are always shown with the lower byte first; that is, the address 0036 is represented in memory as 3600, and the value 0013 is shown as 1300. This is not inconsistent when you think about it, because the lower byte is always stored in the lower memory location. Also notice that QuickBASIC is very organized as it assigns variable addresses—and each variable address occupies the next available memory location.

The second example is compiled to the following machine code, and it is immediately obvious that fewer bytes are needed. All but the first of these instructions use the value held in a register (AX), which is much faster than using a constant value contained within the assembler code instructions.

```
A = 13     C70636000D00    MOV WORD PTR [0036], 13
B = A      A13600          MOV AX, WORD PTR [0036]
           A33800          MOV WORD PTR [0038],AX
C = A      A33A00          MOV WORD PTR [003A],AX
D = A      A33C00          MOV WORD PTR [003C],AX
E = A      A33E00          MOV WORD PTR [003E],AX
```

Because QuickBASIC is very smart, it creates code to retrieve the value 13 from A only once and then uses that value to assign all of the remaining variables. The first example comprises 30 bytes of code, but the second needs only 21.

QuickBASIC lends itself to another clever technique when incrementing and decrementing variables. The simplest type of compiler would take a statement such as X = X + 1 and create code something like this:

```
MOV  AX,[0036] ;move the value of X (address
                36) into AX
ADD  AX,1      ;add 1 to AX
MOV  [0036],AX ;move AX back into X
```

But QuickBASIC is much smarter than that, generating code to directly increment the variable X:

```
INC  [0036]    ;increment X
```

Both INC (increment) and DEC (decrement) are instructions the PC's processor can execute directly, and they are much faster than the ADD or SUB commands.

Array Assignments

Array variables are often initialized in a FOR/NEXT loop, so let's look at that next. The examples below show how QuickBASIC codes a simple FOR/NEXT loop, as well as how variables within it are assigned. In this example, we show the translation much as CodeView does; that is, each line of BASIC source code is shown, followed by the compiled machine instructions.

Notice that the DIM command does not generate assembler code, because memory for a Static array is set aside when the program is compiled.

```
DIM Array(10)
FOR X = 1 TO 10
    B80100          MOV AX,0001
    E90B00          JMP Label2
Array(X) = 0
                Label1:
    8BF0            MOV SI,AX
    D1E6            SHL SI,1
    C78436000000    MOV [SI+0036],0000
NEXT
    40              INC AX
                Label2:
    A30001          MOV [0100],AX  (100 is
                                    X's address)
    3D6400          CMP AX,0A      (10 is 0A
                                    Hex)
    7EED            JLE Label1
```

In the example above, every element in the array is being assigned a value of 0. QuickBASIC uses the AX register as a loop counter and begins by initializing the AX register to the starting count of 1. This is immediately followed by a jump into the NEXT portion of the code, where the value in AX is tested to see if the ending value of 10 (0A Hex) has been reached. If AX is less than or equal to 10, a Jump is made back into the body of the FOR/NEXT loop.

To determine the address of the current array element being assigned, the program moves the X count value held in AX into SI and then multiplies SI times 2 with the SHL (Shift Left) instruction. Because each integer array element comprises two bytes, any element can be found by adding twice the current count to the address of Array(0). For example, the memory location for Array(10) is 20 bytes beyond Array(0).

The actual assignment is made by adding the computed offset held in SI to the constant 0036, which is the address of Array(0). As you can see, QuickBASIC uses the less-efficient method of assigning each element from a constant value. It would have been much more efficient to first clear another register (perhaps BX) to 0 and then use the register for all of the assignments that follow.

Simple Integer Math

Of course, we shouldn't expect QuickBASIC to be as efficient as a human hand coding in assembly language. The code created by any compiler can always be improved. However, as the short program below illustrates, when it comes to simple integer math, QuickBASIC is extremely efficient:

```
X = 4
    C70636000400    MOV  WORD PTR [0036],4
X = X * X
    A13600          MOV  AX,[0036]
    F7E8            IMUL AX
    A33600          MOV  [0036],AX
X = X * 2
    D1E0            SHL  AX,1
    A33600          MOV  [0036],AX
X = X * 3
    B90300          MOV  CX,3
    F7E9            IMUL CX
    A33600          MOV  [0036],AX
X = X * 4
    D1E0            SHL  AX,1
```


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```
    D1E0            SHL  AX,1
    A33600          MOV  [0036],AX
X = X + X
    01063600        ADD  [0036],AX
```

First, X (which is at address 0036) is assigned from the constant value 4. Then AX is loaded from X, where it stays throughout the remaining assignments. To multiply X * X, QuickBASIC generates an integer-multiply instruction (IMUL) and then places the result back into X. Since QuickBASIC is smart enough to realize that AX still holds the value of X, the remaining operations are all performed on AX.

To multiply X times 2, a SHL (Shift Left) instruction is used. It is much more efficient than a conventional multiply: Whenever the bits in an integer variable are shifted left one position, the value is multiplied by 2; likewise, when the bits are shifted right, the value is divided by 2.

Multiplying times 3 cannot be done by shifting, so the CX register is first loaded with the value 3, and IMUL is then used to perform the multiplication. Once this is done, AX is moved back into X. This continues through multiplying times 4, which again is done by shifting.

Finally, the X + X assignment is handled elegantly by the simple addition of AX to the variable's address. Again, this code is extremely efficient, because QuickBASIC is smart enough to realize that AX still holds the value of X from the previous computations.

Another important optimization that QuickBASIC performs is calculating identical expressions only once. In the example below, A is multiplied times B only once for each pass through the FOR/NEXT loop:

```
A = 9
B = 10
FOR X = 1 TO 10
    Array1(X) = A * B
    Array2(X) = A * B
NEXT
```

When examined under CodeView, the program looks like this:

```
A = 9
    C70662000900    MOV  [0062],9
B = 10
    C70664006400    MOV  [0064],0A
FOR X = 1 TO 10
    B80100          MOV  AX,1
    E91900          JMP  Label2
Array1(X) = A * B
                Label1:
    A16400          MOV  AX,[0064]   (64 is B's
                                      address)
    F72E6200        IMUL [0062]      (62 is A's
                                      address)
    8B366600        MOV  SI,[0066]   (66 is X's
                                      address)
    D1E6            SHL  SI,1
    89843600        MOV  [SI+0036],AX
                                (Array1(X) = AX)
Array2(X) = A * B
    89844C00        MOV  [SI+004C],AX
                                (Array2(X) = AX)
NEXT
    A16600          MOV  AX,[0066]   (66 is X's
                                      address)
    40              INC  AX          (AX = AX +
                                      1)
                Label2:
    A36600          MOV [0066],AX    (X = AX)
    3D0A00          CMP  AX,0A       (10 is 0A
                                      Hex)
    7EDF            JLE  Label1 (jump if less
                                or equal)
```

Because neither A nor B is changed inside the loop, QuickBASIC *should* calculate the result only once ahead of time. Even though many C compilers perform that level of optimization, QuickBASIC is not that smart, so you could easily do this yourself to make the program run faster:

```
A = 9
B = 10
Temp = A * B
FOR X = 1 TO 10
    Array1(X) = Temp
    Array2(X) = Temp
NEXT
```

Using CodeView

All of the examples shown thus far would have been impossible to present without the invaluable aid of Microsoft's CodeView debugger. If you are familiar with the QuickBASIC 4 editing environment, you should have little trouble understanding and using CodeView.

Like QuickBASIC 4, CodeView features break points and watch variables, and it lets you single-step through a program. Also like QB4, CodeView can step over or into subprograms and system interrupts. Understand that CodeView is the *only* reasonable way to debug a complex assembler routine that has gone berserk. While DEBUG can be helpful for simple assembly language COM programs, it is all but useless for debugging an assembler routine that has been added to a QuickBASIC program.

Preparing a BASIC or assembler program for debugging with CodeView is very easy—simply add the /ZI switch to the BC or MASM command:

```
BC basicprogram /ZI
```

or

```
MASM asmprogram /ZI
```

Once the program has been compiled or assembled, it must also be linked. This is done by adding the /CO switch when LINK is started:

```
LINK basicprogram [asmprogram] /CO
```

Though the logic escapes me, the LINK switch for a CodeView program is not the same as for BC and MASM. Indeed, /CO is much more sensible, and it's anybody's guess as to what /ZI is supposed to stand for.

For the most part, CodeView is not necessary if your program is written purely in BASIC. After all, the whole point of a high-level language is to avoid having to deal with registers and instructions to the PC's processor. However, if you are creating assembly language routines meant to be called from

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QuickBASIC, it is invaluable. Of course, this is also the only reasonable way to see how QuickBASIC works.

Using CodeView with QuickBASIC

To examine the code that QuickBASIC creates, let's walk through one of the sample programs we looked at earlier. Because we already listed the assembler code created by QuickBASIC, we'll just go over the necessary steps here. We'll get to using CodeView on a mixed program of QuickBASIC and assembler routines in a moment.

First, create a BASIC source file, preferably using one of the examples above, or a short program with just a few simple instructions. When you save it to disk, be sure to use the "Save As" option and select "Text." CodeView has no way to decipher the special "fast load" format that QuickBASIC uses as the default save method.

Next, compile the program from the DOS command line using the BC compiler and the /ZI and /O options:

```
BC basicprogram /ZI /O;
```

Once the program has been compiled, it must be linked:

```
LINK basicprogram /CO;
```

Finally, start CodeView like this:

```
CV basicprogram
```

Once CodeView begins, you see a screen similar to the one used by QuickBASIC. CodeView starts up in the "immediate" mode, so you should press F6 once. At this point, you are viewing the original BASIC source instructions for your program. Pressing the F3 key lets you view the equivalent assembler instructions, but don't do that yet!

Every BASIC program begins with a large section of startup code, which we want to skip over first; so press the F10 key to step to the first line of the BASIC source code. When CodeView is showing your BASIC source file, F10 steps to the next BASIC instruction.

Now you can press F3 to view the assembly language statements intermixed with the BASIC source. Each time you press F10 while in the assembly view mode, a single assembler instruction will be executed. Debugging a mix of BASIC and assembler source is only slightly more complicated, as we are about to see.

Using CodeView with Mixed Languages

While using CodeView with a BASIC program can certainly be an enlightening experience, CodeView really shines when you need to follow a call from BASIC to an assembler routine and back again. As with the BASIC examples above, the assembler source must be assembled with the /ZI switch, and you must invoke LINK with the /CO option:

```
BC basicprogram /ZI /O;
MASM asmprogram /ZI;
LINK basicprogram asmprogram /CO;
```

When CodeView is started, the BASIC source will be presented first, and again you should use F10 to step to the first line in the BASIC program. When you get to a call to an assembly (or other) language routine, press F8 rather than

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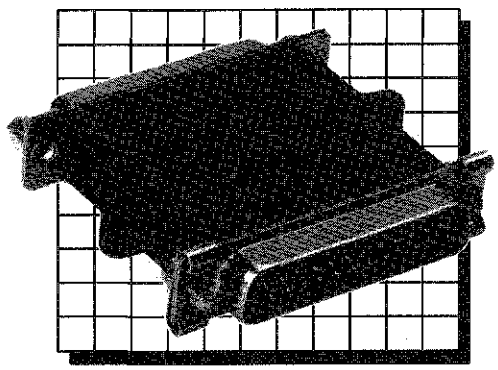

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F10. As in the QuickBASIC editor, F8 steps into a function or subroutine call, while F10 considers the call to be a single instruction and steps over it.

If the assembler source code is not in the current directory, CodeView will ask you to enter the directory name. In order to show both the source code and the machine instructions at the same time, CodeView must be able to load the original source files.

Watching assembler variables is similar to the same operation in QuickBASIC. Pressing Alt-W brings up the Watch menu, and you simply enter the variable's name. Any time the value of a watch variable changes, it will be reflected in the watch window at the top of the screen.

And that's really all there is to it! As long as you remember to use the /ZI and /CO switches, you will have no trouble tracing through either BASIC or assembly language source code.

. . . Well, that's *almost* all there is to it. There are a few bugs in CodeView you should be aware of. (There are several versions of CodeView in circulation; the bugs in the version I have are mentioned below, just so you'll know they aren't your fault if you encounter them.)

The first problem is that CodeView will not work if SideKick is loaded. Mind you, your program won't crash, but CodeView reports the following error:

```
run-time error R6002 - floating point not loaded
```

This error is not mentioned anywhere in the CodeView manual, and it is in fact a C language error message!

The second bug is probably QuickBASIC's fault, because it affects a TYPE variable that uses long integers. In a test program I was writing, the following TYPE declaration was placed early in the source code:

```
TYPE VLong
     Lo AS LONG
     Hi AS LONG
END TYPE
```

CodeView crashed on this one so badly that the power had to be turned off. However, the solution was simple:

```
TYPE VLong
     Lo1 AS INTEGER
     Lo2 AS INTEGER
     Hi1 AS INTEGER
     Hi2 AS INTEGER
END TYPE
```

Since I could use any block of data that was eight bytes, having to split each LONG into two integers wasn't a problem. Depending on what you're trying to do, a different workaround may be needed.

Learning More

We have looked at only a few samples of QuickBASIC code that have been compiled to machine instructions. Of course, many BASIC statements are difficult to follow once they have been compiled because of the complexity of QuickBASIC's system of library calls. However, tracing through some of the simpler functions can be very enlightening.

I encourage you to experiment on your own, perhaps looking at such functions as LEN and ASC, to see how these functions work. Indeed, my own curiosity led me to develop more-efficient replacements for these commands. ♦

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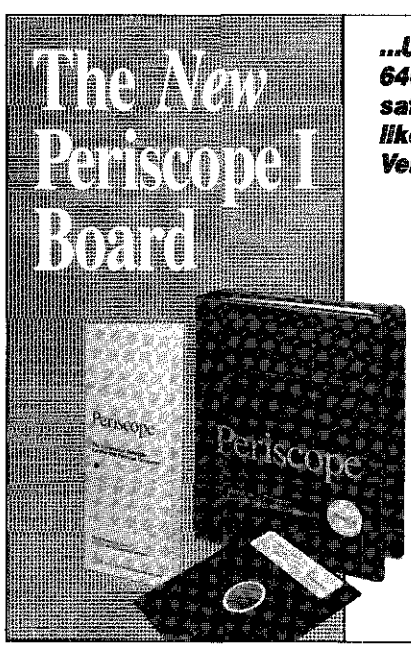

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The Proposed ANSI C Language Standard

by
Rex Jaeschke

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Lattice V3.3 for DOS and OS/2

At one time, Lattice was one of the major players in the DOS-based C compiler business. However, in recent years they have seen some stiff competition. They were acquired by SAS Institute, and they have had some financial and other reorganizations, all of which have affected their presence in the marketplace. In fact, when SAS acquired Lattice, Lattice lost their voting status on the ANSI standards committee, since each company is permitted only one voting member. However, that does not prohibit such companies from attending meetings and actively participating in the discussions.

Lattice has not been beating their drum and claiming they are tracking the ANSI standard—although their packaging and documentation might lead you to believe they are. I guess that's just marketing license. In any case, the preprocessor, compiler and library all come up considerably short with regard to ANSI-standard conformance.

The Compiler Options

A few compiler switches are worth mentioning: -cs causes like string literals to be "pooled," with only one copy actually stored; -cu makes plain chars unsigned instead of signed; -cw disables warnings for nonvoid functions having no return values. Be careful about using this: While it may save lots of messages if your code was written before void functions were permitted, it will not tell you if you have made a legitimate error. I strongly suggest that you declare void functions as such, rather than defaulting to ints without returning a value.

The -F option generates function prototypes from existing source; however, this option has shortcomings and bugs. For example, an int function defined with no arguments has an ANSI prototype of int f(void);. The Lattice compiler does *not* put the void inside the prototype, thereby rendering the generated prototype almost useless. Having nothing inside the parentheses tells the compiler not to check the calling argument list when, in fact, it should make sure there are no arguments.

Additionally, the new style of defining a function is not supported. In the old K&R style, any argument having a narrow type was really passed in its widened form; however, when a char argument was declared, it was retained as a char in the prototype generated, while it should have been made an int. Strangely enough, a short argument was correctly made an int, and a float was correctly made a double.

Another bug occurs when an argument is declared as type short *. This was incorrectly changed to int * in the prototype, which could have disastrous affects if you moved your code and prototypes to a machine on which short and int had different representations. A final problem is that each prototype in the output file is terminated with a line feed rather than with a carriage return–line feed combination; the file is not particularly readable when you type it out using the DOS TYPE command. Depending on your editor, you may also have trouble editing it. This option definitely needs a lot of work.

The -x option lets you write all occurrences of external data declarations without the extern keyword. The K&R and ANSI models require one—and only one occurrence—not to have the extern keyword; all other references must have it.

The Preprocessor

The following ANSI C attributes are not supported or had some limitation:

- Macros are limited to 16 arguments.
- Macro arguments are replaced inside strings and character constants.
- A macro can be redefined. The preprocessor stacks the different definitions and produces a warning.
- No #, ##, or "defined" operators are supported.
- No predefined macros exist for __DATE__ and __TIME__. Therefore, these and other macros (__FILE__ and __LINE__) are allowed to be #undefed.
- No support is provided for arbitrary token continuation using a backslash–new line pair.
- Excess tokens on directive lines are ignored.
- Tokens are built incorrectly in certain circumstances.
- Comments are permitted to span source files.
- Explicit, long int constants in #if expressions are a problem —#if 10/0 hung the compiler (and the PC).
- No #elif is supported.
- No #include identifier is supported.
- No #error or #pragma is supported.
- ANSI C permits "sizeof" to be rejected by the preprocessor but does not require it to be. Lattice rejects it.

I encountered a bug when a macro M was defined with arguments and a declaration of int (M)(); was used. The declaration was incorrectly recognized as a call to macro M; however, since the token immediately following the M is not

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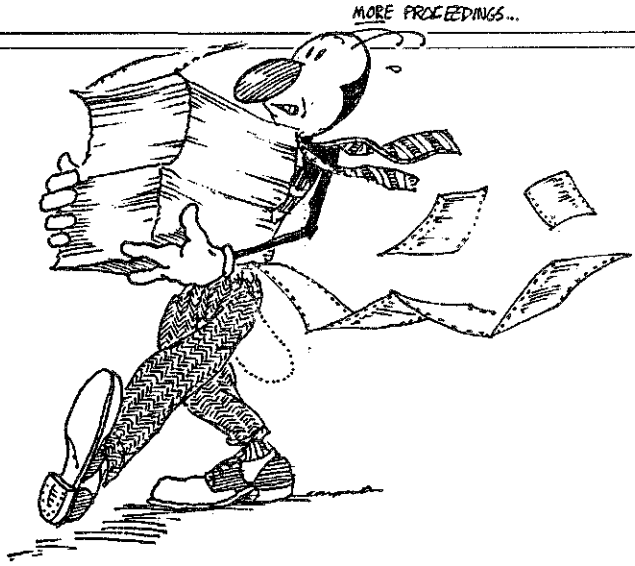

a left parenthesis, it is not a macro call. (I have found this error in numerous compilers.)

The C Language

The following ANSI features are not supported:

- Bit-fields in unions
- Initialization of auto arrays and structures
- The new keywords const, volatile, and signed
- Concatenation of adjacent string literals
- Long double type or long double constants
- Float constants
- Unsigned constants
- Trigraphs
- String literals up to 509 characters

Void pointers are supported.

Function prototype support has been partially implemented. A function declaration is permitted to have type declarations in place of each argument expected. The trailing ellipses are also supported for variable argument lists. Note, though, that the ellipses can also be omitted, leaving a comma followed by a right parenthesis. This is not permitted by ANSI C and was an interim stage of the design during ANSI deliberations. Don't use it. The only real drawback is that dummy identifier names are not permitted in prototypes. Also, the new prototype style of defining functions is not supported.

In numerous examples in the manual, main is declared as a void function. Not only is this never true, but it teaches bad programming practices. If you never return a value from main and you want to be rid of the warning the compiler generates, return a value of zero instead.

The Runtime Library

The library and headers are pretty much K&R vintage, with the usual UNIX stuff thrown in. Of the 15 headers defined by ANSI C, four are "missing": errno.h, stdarg.h, stddef.h, and locale.h. Actually, errno.h is implemented as error.h. Surprisingly, the old UNIX equivalent of stdarg, varargs.h, is also absent.

It is clear that Lattice sells their compiler to the Asian market since there are switches for handling multibyte character sets for Japan, China and Taiwan, and Korea. However, they have not yet chosen to implement the locale.h header and its corresponding library support. This, along with numerous other library macros and functions, was specifically designed by ANSI to support these environments.

The ANSI-standard headers provided (or their equivalents) contain many extended macros and functions. They are also missing many ANSI macros and functions. The ANSI differences are too numerous too mention here. Suffice it to say that the current release of the library and associated headers clearly does not attempt to be "like ANSI."

Most annoyingly, I found that the standard headers are not precluded from being #included more than once, and they should be. Many programs explicitly #include stdio.h directly and indirectly multiple times. Of course, doing so without protecting your headers results in the generation of many compilation errors. The first thing you should do when you install the Lattice product is put a conditional compilation envelope around each header as follows:

```
/* in stdio.h */
#ifndef __STDIO__
#define __STDIO__
/* distributed header body goes here */
#endif
```

The Bottom Line

Lattice C is quite far from conforming to the proposed ANSI C standard. However, Lattice is not ignoring it—they just seem to be concentrating on OS/2 and other things at present. They have implemented a few choice bits and plan to add a few more in V3.31 soon. You will probably have to wait for V4 (or perhaps V3.4?) to get much more of the standard's goodies. Lattice has their own devoted customer base, who no doubt will be quite happy with the new capabilities this release provides. However, for the time being, I don't see Lattice stealing sales from such companies as Borland and Microsoft, whose implementations are much more modern.

ANSI C Standard Activities

At the September 1988 meeting of ANSI C X3J11, the committee unanimously voted in the draft standard as a formal standard. Unless we messed up administratively or one or more ANSI X3 members vetoes it, the standard should be adopted by ANSI around March or April of 1989. It is hoped that ISO will adopt the same standard later in 1989. The National Bureau of Standards has begun work on a validation suite, and I have agreed to be the liaison on behalf of the ANSI C Standards Committee. ♦

Rex Jaeschke is an independent computer consultant, writer, and lecturer. He is also a member of the X3J11 C Standards Committee, observer on the ISO C Standards Committee, founding editor of The C Journal *and the C language editor of* DEC PROFESSIONAL. *His new book,* Portability and the C Language, *published by Hayden Books in October, is the first text on this popular topic.*

If you would like to comment on, or question any aspect of, ANSI C standard, the validation suite, or the validation process, write to Rex Jaeschke at 2051 Swans Neck Way, Reston, VA 22091, or contact him electronically via UUCP at the following address: uunet!aussie!rex. Rex will endeavor to address your concerns in future columns as space permits.

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Smart Terminal Emulation in Windows

by
William S. Hall

Writing a terminal emulator in Windows offers many challenges not normally encountered in the character-based DOS world. But if you can overcome the sometimes surprising difficulties, you can reap many benefits: a rich user interface of dialog boxes and menus, multitasking and data exchange with other applications, the ability to implement special-purpose fonts, and a communications device driver with a complete set of function calls.

About a year ago, I decided to attempt a complete emulation in Windows of the well-known Heath H-19 terminal. The results have been successful, and I'd like to tell you how it was done. I won't overwhelm you with code (although I will use some fragments to illustrate certain points). Rather, I'll emphasize the overall architecture of the emulator, the realization of special features of the terminal, and some of the problems I have encountered and overcome. I'll concentrate primarily on aspects unique to Windows, but I will try to remember that most of you may not have yet acquired an intimate knowledge of the Windows programming environment.

I'll begin by describing the terminal itself. Then I'll discuss an architecture that can be used to implement most of the features of the terminal. Sprinkled throughout will be information about Windows features that must be taken into account in a project of this type.

If you want to see working source, I have provided some extracts illustrating some of the major points to the *PJ* bulletin board. The code consists of two of the five modules, of which the first contains the main window procedures and the second, many of the supporting modules. Emphasis is on those items providing keypad support and communication processing.

The H-19 Terminal

The Heath/Zenith H/Z-19 terminal first appeared about ten years ago. It was amazingly successful, considering that it was created by a rather small company at a time when there were many large and well-known computer terminal manufacturers. A great deal of its success was probably due to its emulation capabilities, its price, and the fact that you could build the terminal from a kit. Thousands were bought by universities, companies, and individuals, and the H-19 proved to be one of Heath's best products. It remains a popular emulation model: The Windows Terminal program contains features of the H-19, MS-DOS Kermit provides H-19 as a terminal type, and although the H-19 is no longer manufactured, it lives on in its successors such as the H/Z-29 and in the Zenith Z-100 computer.

The H-19 is capable of both VT-52 and ANSI emulation and has a so-called Heath mode as well. The Heath mode, in fact, is simply a small but significant enrichment of the VT-52 command set. The Unix operating system recognizes the difference and uses a separate TERMCAPS file. However, if the particular host computer doesn't know about the H-19, you can always set a terminal type of VT-52 with no major loss in functionality. Of course, ANSI mode can also be used. ANSI mode is more or less similar to the VT-100 or VT-102.

The terminal is basic in the sense that it provides a fixed width of 80 columns and a height of 24 lines, but there is also a status line at the bottom that can be accessed only by software commands. As such, it can be used as a protected field. The H-19 also has a set of simple graphics characters. Finally, a character can have only one attribute—that of inverse video.

Every command to the terminal begins with the escape character. In Heath/VT-52 mode, an escape sequence is at most three characters long. For ANSI mode, a sequence is arbitrarily long. The commands are shown in Figure 1.

In addition, the H-19 has a set of special keys that supplement the normal control and alphabetic keys. These include eight function keys that send fixed escape sequences, reset, an on line–off line key, a break key, and a 12-key keypad. The keypad can be used either for numerical entry in normal mode or as a set of editing keys in shifted keypad mode. Finally, in alternate keypad mode, the numerical keys and the associated decimal and Enter keys send out three-character escape sequences instead of numbers.

Almost all these features can be achieved in Windows; however, some are nearly impossible, and some are much harder than others. For example, the first two categories of commands listed above are not difficult. By developing a dedicated font resource, you can achieve the special graphics characters on the H-19. On the other hand, it is hard to turn off key click without specific hardware knowledge of the particular computer, and hold-screen mode is not so natural in Windows as it is on a dedicated terminal. Another problem is making a faithful emulation of the H-19 keypad: The keypad keys in Windows don't follow the same protocol. Finally, not all the keys on an H-19 are found on most computers able to run Windows.

Some Windows Basics

At this point it may be useful to look at the basic layout of a Windows program. Most programs can be abstracted into the following form:

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```
WinMain(...) {  /* entry point */

     Init(...);    /* register classes, create
                      windows, init data */
          while (GetMessage(...) { /* read and
                dispatch messages until exit */
               TranslateMessage(...);
               DispatchMessage(...);
          }
     exit();
}

WindowProc1(...) {  /* window procedure for
                       windows of class 1 */
     switch(message) {
          case WM_1:
               f1(...);
               break;
          case WM_2:
               f2(...);
               break;
          .....
     }
}

WindowProc2(...) {  /* window procedure for
                       windows of class 2 */
     switch(message) {
          case WM_1:
               f3(...);
               break;
          case WM_2:
               f4(...);
               break;
          .....
     }
}

f1(...)          /* support functions */
f2(...)
f3(...)
f4(...)
...
```

Essentially, every Windows program remains in the message loop, reading, possibly modifying, and dispatching messages until the program exits. The messages contain input from the mouse and keyboard, requests to redraw the window client area, and other information of various kinds. Windows itself calls the appropriate window procedure, which in turn calls any support functions—local or otherwise—to perform the required tasks. Messages can come from Windows, from the program itself, and from other programs. Typically, a window procedure is a large case statement switching on the message type. Message types are predefined by Windows (WM_CHAR, WM_PAINT, etc.) or user defined by the program (WM_USER, WM_USER+1, etc.). Finally, each message contains one 16-bit and one 32-bit quantity, whose meaning depends on the message type.

Which window gets the message depends on the window's handle. Which window procedure receives and processes the message depends on the window's class. Basically, a window class defines certain attributes shared among all windows of that class, such as the style, window procedure, instance handle, icon, cursor type, background brush, and menu. The class concept abounds in Windows. Several classes, such as edit windows, pushbuttons, listboxes, and static windows, are predefined. Most top-level windows in a program are of a unique class determined by the program itself. In particular, a class can be defined to perform particular tasks by simply specializing its window procedure. You will see how we exploit this idea by defining a smart terminal class in our emulator.

It is worth noting that in our emulator we do not use the message loop described above. The problem is that the **GetMessage** call can't be used to service the communications port. Later, you'll see how this problem can be solved.

Isolating Functionality

A terminal is an I/O device with two sources of input and output. Input can come from either the keyboard or the communications input port. Output can be displayed on the screen or sent to the communications output port. The internal devices can be connected in several ways. For example, when the terminal is off line, keyboard input is displayed on the screen. If on-line, the input to the display comes from the input port and the output port gets its data from the keyboard. Finally, the keyboard may send data to both the display and the port if local-echo is active.

In a Windows emulation of a terminal, the communications device driver provides the port interface, and it is obvious what role the computer's keyboard will play. And, clearly, a window must act as the display screen of the terminal, but what kind of window? The top-level, or main, window in a Windows program can be resized, moved, and suspended (made iconic). It is not a permanently fixed object;

Cursor Functions:
Cursor home, forward, backward, up, down, reverse index, position report, direct addressing, save/restore cursor position.

Erasing and Editing:
Clear display, erase to beginning and end of display, erase line, erase to beginning and end of line, insert and delete line, delete character forward, enter and exit insert mode.

Configuration:
Reset, modify baud rate, enter ANSI mode, enter Heath mode, set and reset status line, key click, hold screen, cursor type, shifted and alternate keypad, auto CR on LF, auto LF on CR.

Modes:
Normal and reverse video, graphics and normal characters.

Other:
Enable and disable keyboard, wrap around, transmit status line, transmit screen.

Figure 1

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you can imagine the difficulties in performing smart terminal operations in such circumstances. Furthermore, the status line, which on a terminal normally appears at the bottom of the screen, must always be visible if active—even if the window representing the main screen is smaller that the maximum number of lines.

These problems suggest that the screen can be represented by a child of the main window. The child is fixed in size; its actual dimensions in device units are determined by the number of lines and columns in the target terminal and by the font size. The main window thus acts as a viewport into the child and hence of the display screen, as shown in Figure 2.

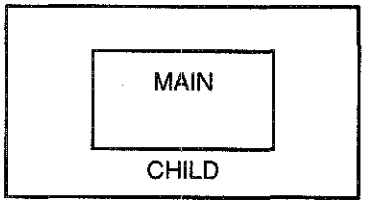

Figure 2

Of course, the main window can be as big as or bigger than the child as well.

Similarly, the status line should also be a child of the main window. Its placement is on the last full line of the main window when it is active. In this way, it will always be visible.

Although child windows can have title bars, borders, and some other attributes, they cannot have menus. So the task of providing the user interface is best left to the top-level window. Such considerations suggest the arrangement of the windows in a terminal emulation program shown in Figure 3.

Once these decisions about the chores of the various windows are made, the modules of the program become more clear. In Windows, it is good practice to isolate functionality into separate segments. Each segment might have one or two entry points and a group of local support functions. The segments are allowed to move, and most are marked as discardable. Here is how I arranged my program:

1. A segment for the main window, which includes the main window function and all functions it calls. In addition, the message reading loop and communications input processor are in this segment. This segment also contains the command processor for any received escape sequences and dispatches all input to the display windows.
2. A segment for the terminal and status windows, which includes their respective Window procedures and all functions called in response to such messages. Hence, all editing and display functions are in this segment. These functions can be reached *only* via the message system.
3. An initialization segment, which can be discarded and is never needed again.
4. A segment containing rarely called functions such as dialog box procedures and which is loaded only upon demand.
5. A resource segment containing error messages and other strings not needed during normal operation as well as icons, dialog boxes, and menus.
6. A data segment containing global variables and the heap with the terminal buffers.

Now let's look at some of the pieces of the program.

The Display Windows

In Windows terminal emulation, it is quite natural to define a class that can perform all the output functions of the target terminal. In the H-19 emulator, I defined a smart terminal class whose window procedure contains many of the features needed for an intelligent display device. The *only* way to gain entry to the window is via the message system. Most of the messages the window can process are user defined. They include

1. Create, display, hide, and destroy the caret.
2. Display and redraw text in the appropriate font and attributes.
3. Maintain the text buffer.
4. Position the caret to any position and return the location.
5. Scroll the display up or down.
6. Insert and delete n characters on a line.
7. Insert and delete n lines of text.
8. Clear screen completely or selectively.

Such a window can serve a variety of emulations. It is only necessary for the command processor to interpret a given escape sequence (or keystroke) as the appropriate message and send it to the window procedure.

Similarly, a window class can be defined to provide status line support. Since it is a single line, the corresponding window procedure just needs to respond to a subset of the above actions.

Because the display windows have a fixed size, it makes sense to talk about a given line or column number, even if that position is not visible in the main client area. On the other hand, several interesting problems can arise. For example, the line on which the caret (the character insert point) is placed must always be visible, so each time the caret moves to another line, a check must be made to see if that line is still visible in the main window. If not, the display window may have to be moved vertically. In turn, if the window is moved, it must be redrawn, which can slow things down. I found that a fast way to perform the positioning is to move the window with no

Main window:
Supports input and communications activities and manages all aspects of the user interface.

Terminal window:
A child of the main window, it is of fixed size and handles all output except for the status line.

Status window:
A child of the main window, it is of fixed size and handles output to the status line.

Figure 3

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redraw, scroll the display surface accordingly, then update the window. Usually the scroll preserves most of the contents of the window leaving only a small rectangle that must actually be repainted.

The text to be displayed is sent to the display window using a user-defined message. The word parameter is the length, and the long parameter is a pointer to the character string. The display window must not only show the characters, but it must also maintain a buffer of the screen's current contents. Unlike in DOS, where it is enough to place the character/attribute pair into video memory to see it on the screen, the program must also carry out the necessary steps to show the character as well. This can be done as the string is being processed. Or, and aesthetically more satisfying, the characters can be placed in the buffer and the corresponding rectangle on the screen where they will appear can be marked as invalid. A paint message will then be generated with that rectangle as the update region. In response, the paint function for the window draws the new text. Of course, the programmer must write the paint function as well.

The advantage of the show-when-received approach seems to be a smoother, faster display. In addition, control characters, which may generate scrolling of the display and the video buffer, can be processed as received. The advantage of the invalidate-rectangle technique is that text drawing functions can all be in one place.

Another problem comes up in handling the caret. The caret, or character insert point, is a shared resource in windows. Only one program can have the caret. When a window receives the focus for input, a message is sent and the caret can be created. When the focus is lost, the application is again informed and the caret must be destroyed. But smart terminals can be commanded by an escape sequence to change the shape of the caret from, say, block to underline, an action that requires destroying the current caret and recreating it. Since Windows is multitasking, such commands can be received by the display window via the communications port even if the program does not have the focus. Arbitrarily destroying and recreating the caret without regard to ownership is not polite of an application, so care must be taken with this resource.

Since the display window is frequently bigger than the main client area, unless the main client window is exactly an integral number of lines high, a part of the last line can be visible. I solved this problem by setting the size of the status window when inactive to be as high as the remaining visible partial line and placing it just below the last full line on the screen. This window is also always "on top" of the display window. In this way, it defines a clipping region in such a way that no drawing takes place in this "barrier" region. If the status line becomes active, it is increased in height by one line as well so that the text can be displayed on the last full visible line. Arriving at this solution was not an instantaneous process; I tried many other tricks before discovering this one. In addition to greatly improving the display, with this solution the status line is always in the correct position to be seen by the user, providing, of course, that the bottom of the main window is visible.

Off-line Input Processing

Having discussed some of the problems involved in displaying text, we need to look at getting input. Input can come from the keyboard if the terminal is off-line, or from the

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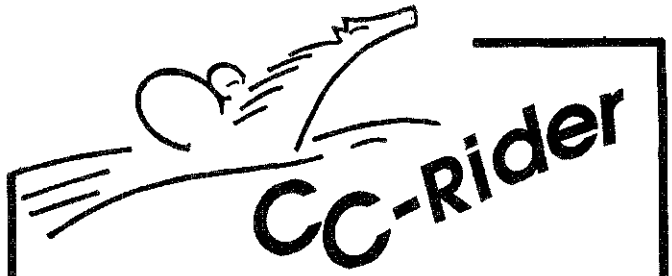

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communications port if on-line. It may be a bit simpler to understand the process if we look first at the case when the terminal is off-line. In this case, the terminal acts as a typewriter.

Windows provides an asynchronous way of receiving character input. Whenever a key is typed, three messages are generated—WM_KEYDOWN, WM_KEYUP, and WM_CHAR. The first indicates that the key has been depressed and the second, that it has been released. Finally, if the character is printable, the virtual key code, which is part of the keydown/keyup message structure, is realized as an ANSI character in the WM_CHAR message.

In our program, all input is handled by the main window procedure. When that window has the focus, keyboard messages can be received. If the terminal is off-line, printable and control characters are shipped as one-character strings to the appropriate child window. The main window maintains an active handle variable and simply sends the message to that window. If the status line is the active window, the character will appear there; otherwise, the display window will receive the character. (The status window becomes the active window only if it has been turned on by the appropriate escape sequence and if a command sequence has been received to move the caret to the status line.)

If the escape character is typed, the state of the command processor changes, and the appropriate number of characters that follow are processed as a command. If the command affects the display, such as movement of the caret, the corresponding message is sent to the active window; otherwise, it is handled locally, as is, for example, a sequence to change the baud rate. If an edit key is struck (one of the keypad keys, for example), WM_KEYDOWN message is translated into an editing command for the display and the corresponding message is sent to the active window.

Edit keys, such as cursor motion keys, are interpreted as commands for the displays, and appropriate messages are sent to the active display window. Finally, certain function keys can have an effect on the terminal. For example, F6 has been dedicated to mimic the H-19 CLEAR key.

The actual processing of editing keys is very complicated, since the goal was to emulate the exact action of the H-19. We will discuss this some more later.

Modifying the Message Loop

It is easy to get character output to the communications port when on-line; whenever a WM_CHAR message is received from a call to **GetMessage**, write the character to the port. The problem is how to know when there are characters to be read; no message is sent when the communications port read buffer is not empty; instead, the communications driver must be polled. But if the program waits on the port and does not read messages, all other Windows programs will stop until the next **GetMessage** call.

There is a way around the problem. It is possible to replace the **GetMessage** call with **PeekMessage**. When **PeekMessage** is called, the program yields to all other tasks, which then execute in turn. Control then returns to the program, even if there is no message. So tasking and polling can be maintained with the following kind of message loop:

```
while(TRUE) {
    if (PeekMessage(...)) {
        if (message == WM_QUIT)
```


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```
                exit();
            else {
                TranslateMessage(...);
                DispatchMessage(...);
            }
        else
            ProcessComm();
    }
```

PeekMessage returns non-zero if a message is read, and it is dispatched the same as before. If there are no messages, however, the communications buffer can be polled in **ProcessComm** and any characters present can be read and dispatched to the command processor of the emulator.

Window Subclassing and On-line Processing

When a terminal goes on-line with no local-echo, the keyboard and screen are disconnected from each other and are connected to the communications port device. If local-echo is on, the keyboard remains connected to the screen as well.

Similarly, in the emulator the action taken upon receipt of the WM_CHAR, WM_KEYDOWN, and WM_KEYUP messages changes. Characters are now routed to the communications port, and edit keys send the expected escape sequences to the host computer. If local-echo is also in effect, however, the keyboard must also act as if it were connected to the display. Such action can be easily achieved by a technique known as *subclassing*. Here is how it works.

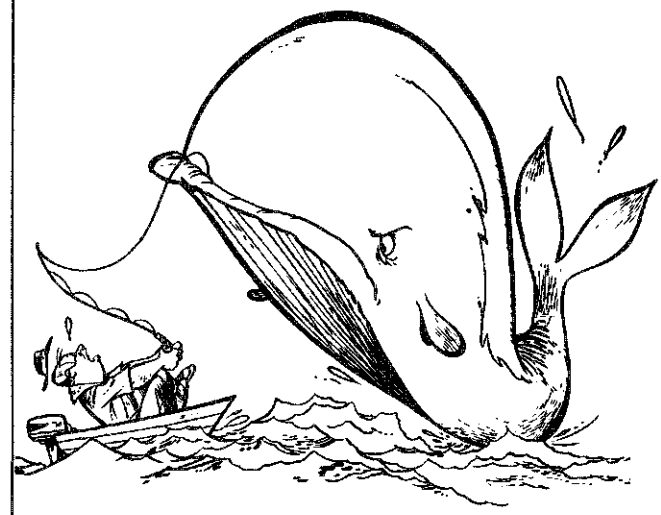
Suppose the main window has a procedure that looks something like this:

```
MainWndProc(...) {
    switch(message) {
        case WM_CHAR:
            DisplayCharOnScreen();
            break;

        ....

        default:
           return(DefWndProc(...));
    }
    return (0L);
}
```

We now write another one:

```
SubClassWndProc(...) {
    switch(message) {
        case WM_CHAR:
            WriteCharToPort();
            if (!local_echo)
                break;

        default:
            return(CallWndProc((FARPROC)
                   MainWndProc(...)));
    }
    return (0L);
}
```

When the terminal is placed on line, the main window's window procedure is changed to point to the subclass procedure, which can be done with a single call to Windows. WM_CHAR messages are now routed to the communications port, and all other messages are simply passed on to the main window procedure. But if local-echo is on, WM_CHAR messages also go on to the main window procedure, since the case statement now falls through to the default action.



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Of course, we use subclassing for more than just handling the WM_CHAR message. It is a powerful technique. Subclassing gives the programmer the ability to alter the behavior of any window whose handle and instance handle can be obtained. This includes the predefined ones, such as dialog boxes.

Special Keys

You may have observed the call to a perhaps mysterious function, **TranslateMessage**, in the message loop. This windows function simply converts WM_KEYDOWN and WM_KEYUP messages from Windows into WM_CHAR messages if a printable character for the keystroke exists. By controlling and modifying the keystroke messages and their translations in the message loop, I was able to achieve a precise emulation of the H-19 keypad as well as other special keys.

The H-19 keypad appears as follows:

IC(7)	**Up(8)**	**DC(9)**
Left(4)	**Home(5)**	**Right(6)**
IL(1)	**Down(2)**	**DL(3)**
0	**.**	**?**

The ? means that we do not have the extra Enter key on IBM PC 83-key keyboards, and at this time, we have made no effort to emulate it.

The operation of the keypad on the H-19 requires some explanation. Generally, it can be in normal, normal shifted, alternate, and alternate shifted modes. Each one of these modes can be set with an escape sequence. The output from a keypad key depends on the mode. For example, if we press the Up arrow key in normal mode, the digit 8 is sent. But if we press the Up arrow in alternate keypad mode, the sequence Esc ? x is transmitted. These actions are further modified if the Shift key has been depressed.

To emulate this action in Windows, it is necessary to translate the virtual key codes from the keypad to the ones desired. Furthermore, it is sometimes necessary to inhibit translation to WM_CHAR messages. Continuing the example above, if we are in normal keypad mode and we receive the VK_UP message, we have to convert this to the corresponding VK_NUMPAD message—in this case, VK_NUMPAD8. Then, since we want the key to be displayed as an 8, we let translation take place. If we are in alternate keypad mode, we make the same conversion without allowing translation. In this case, only a WM_KEYDOWN and WM_KEYUP message will be seen, but the WM_CHAR will not. When the WM_KEYDOWN message is received, we can then send out the Esc ? x sequence.

Similarly, conversion of VK_NUMPADn messages to the corresponding edit keys may be needed, depending on the settings. All together, there are 8 combinations.

To complicate the issue, the position of the PC Num Lock key will modify the messages expected. As implemented, the keypad works correctly with this key in either position; this was rather difficult to achieve.

A similar problem is the lack of a break key in Windows. In this program, Ctrl-Break is used. Normally, this key is translated to Ctrl-C. By inhibiting translation, we can use the keydown message as a signal to turn break on, and the keyup message to turn break off. At the same time, we are assured that Ctrl-C is not also transmitted.

You might want to compare what we have done with the use of accelerators in Windows, where the accelerator keystroke not only is not translated, but it is also not even dispatched directly—it is converted to a WM_COMMAND message. In our case we let it go through, but we may modify its value, and we control its translation.

Miscellaneous Features

The H-19 terminal has two dip switches that determine the power-up state of the machine. The analogy in Windows is the **win.ini** file. When the emulator is first run, it reads **win.ini** and sets initialization parameters accordingly. On the terminal, all parameters except local-echo mode can be changed as needed by going off line and typing in an escape sequence. This is still possible on the emulator, but it is easier to use the menus and dialog boxes provided. In addition, settings can also be written to **win.ini**.

The H-19 character set is 7-bit ASCII. The characters are 7 bits by 9 bits in an 8-by-10 cell. In addition, there are 33 special characters that provide limited graphics capability. Using the Windows font editor, I was able to build a font resource in which the graphics characters are identical to the original. Note, however, that the normal characters had to be weighted a bit more heavily in the vertical direction to achieve a good appearance on the white Windows screen. The graphics characters occupy the otherwise empty positions of the control characters, which may explain why exactly 33 were provided on the H-19.

Each character can have the attribute of inverse video. The inverse video attribute is stored in the video buffer with the eighth bit set. When the character is displayed, the screen and background colors are interchanged just before the bits are written to the screen.

Some features of the terminal were rather difficult to implement. One of these was hold-screen mode, where a line (screen) is displayed and then the display stops scrolling until Scroll Lock (Shift–Scroll Lock) is pressed. Part of the action requires dynamically modifying the state of the Scroll Lock key, which is possible in Windows 2.0. Unfortunately, the Scroll Lock light does not follow the state on AT and enhanced keyboards.

Another problem was transmitting the contents of the status line or the entire screen. Each group of characters in the screen buffer must be sent along with the commands that set its attributes. For example, if a set of characters is graphics and in reverse video, the sequences to put the terminal into reverse video and to set graphics mode must precede the characters. Ideally, if an H-19 screen is sent to another H-19, the appearance should be the same on both. To this end, I allocate space in the Windows global heap and move the characters there while determining the necessary escape sequences. Then they are read back to the communications port a line at a time whenever Windows returns to the emulator from **PeekMessage**. In this way the screen or status line can be transmitted while other Windows programs continue to run.

Finally, let me mention that text data can be "pasted" from the Windows clipboard. We thus have a rudimentary file transfer, although it is not very reliable if the host computer is easily overwhelmed by too many characters at once. *Pasting*, in this case, means actually sending the characters as if they were being typed at the keyboard. As they echo back on the screen, it appears as if they were actually placed there rather than simply sent to the communications port. The techniques used in sending a line or screen were useful here, although it is not necessary to format the text, since we assume that no special H-19 character attributes need to be supplied.

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Performance

Windows has been criticized for not being a good real-time system for rapid display of text. Under Windows 2.0, however, text display has been greatly improved despite the fact that the Windows screen is always in a high-resolution graphics mode. I have found that with proper flow control (XOFF- XON, for example), communications at 9600 baud are quite satisfactory on the EGA, VGA, Hercules, 8514A, or the Olivetti/AT&T 640x400 monochrome displays.

Conclusion

In this project, I have made strong use of such Windows features as the menu/dialog box user interface, the rich set of communications functions so lacking in DOS, and the ability to use special fonts. I have even been able to base a Windows version of Kermit on the emulator. Even so, I've exploited only a small part of Windows' real capability. Yet to appear are emulators of some of the popular graphics terminals, but that is a natural application of Windows. I hope the information here may point you in that direction if you are so inclined and that it has, at the very least, acquainted you with the special considerations that are necessary in the Windows environment. ♦

As a Senior Engineer at Olivetti Advanced Technology Center in Cupertino, California, Bill Hall specializes in Windows system support software.

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— SUBEXPRESSION —

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Mail order information on pages 8 and 88.

Code from "Smart Terminal Emulation" by William S. Hall

1

```
/* Windows H19 emulator
 *
 * Written by William S. Hall
 *           3665 Benton Street, #66
 *           Santa Clara, CA 95051
 * Program entry module and Emulator function support module-extracts
 */

/* Windows entry point */
int FAR PASCAL WinMain(hInstance, hPrevInstance, lpszCmdLine, cmdShow)
HANDLE hInstance, hPrevInstance;
LPSTR lpszCmdLine;
short cmdShow;
{
   /* Initialization */
    if (!InitProgram(hInstance,hPrevInstance, lpszCmdLine, cmdShow))
        return FALSE;

  /* Message loop */
    while (TRUE)
        if (!DoMessage()) /* if message, process it */
            ProcessComm();    /* if none, then take care of communications */
}

/* Message processing loop.  Return false if no message. */
BOOL NEAR DoMessage()
{
    MSG msg;

  /* Look for a message.  If we have one, remove and process it. */
    if (PeekMessage((LPMSG)&msg,NULL,0,0,PM_REMOVE)) {
      /* have to exit. */
        if (msg.message == WM_QUIT)
            exit((int)msg.wParam);
       /* got a key from accelator table.  All shifted, control,
        * and shifted-control function keys are in this table.
        * We convert them to a WM_COMMAND message and process them there.
        */
        if (TranslateAccelerator(MW.hWnd,hAccel,(LPMSG)&msg) == 0) {
           /* DoKeyTranslation is our own function.  Here we
            * decide if a key down/up message should be translated to
            * a WM_CHAR message, or if the wParam should be changed
            * to another virtual key code.  If true is returned, the
            * key is translated.
            */
            if (DoKeyTranslation(msg.message, &msg.wParam))
                TranslateMessage((LPMSG)&msg);
            /* Tell Windows to call our message procedure. */
            DispatchMessage((LPMSG)&msg);
        }
        return TRUE;
    }
    return FALSE;
}

/* This complicated routine reads the comm port when on-line provided
 * the buffer is empty.  Otherwise, it looks to see if anything
 * is left over from a previous attempt at processing.  Normally,
 * the buffer is completely emptied when it is sent to the main
 * window procedure.  However, if hold-screen is in effect, then
 * the terminal window will stop display whenever a carriage return
 * is seen.  In this case, the remaining buffer remains unprocessed
 * until the scroll-lock key is toggled and another line (or screen)
 * can be displayed.
 */
void NEAR ProcessComm()
{
    COMSTAT ComStatus;
    int num;
    int retresult = 0;
    int result = 0;
    static char Buffer[COMMQUESIZE];
    static int bufsize = 0;

    /* if on line, continue */
    if ((CD.LineState == IDM_ONLINE) && !CD.ScrollLock) {
      /* if the buffer is empty, read the comm port */
        if (bufsize == 0) {
            GetCommError(cid, (COMSTAT FAR *)&ComStatus);
            /* if we find something in the comm buffer, get it */
            if (num = ComStatus.cbInQue) {
                num = min(num, BUFSIZE);
                /* if error, ignore and pass the string along anyway */
                if ((result = ReadComm(cid, (LPSTR)Buffer, num)) < 0) {
                    result = -result;
                    Buffer[result] = NUL;
                }
            }
        }
        else
            result = bufsize;
      /* We got something on the last read, or the buffer was not empty
       * because the previous dispatch did not read all of it.
       */
        if (result) {
            retresult = H19StringInput(Buffer, result);
            /* if still not empty, move remaining to front of buffer */
            if (retresult) {
                bufsize = retresult;
                memmove(Buffer, Buffer+result-retresult,retresult);
                Buffer[bufsize] = 0;
            }
            else
                bufsize = 0;
        }
      /* If nothing immediate to process, then check out global buffer
       *   in case something from the clipboard is there.
       */
        else if (GB.hBuf) {
            BYTE FAR *tbuf;
            LONG BufBytesRemaining;
            int count;

            /* if not empty, then get another line from buffer */
            BufBytesRemaining = GB.lBufTail - GB.lBufHead;
            if (BufBytesRemaining > 0) {
                tbuf = GlobalLock(GB.hBuf) + GB.lBufHead;
                if (BufBytesRemaining > INT_MAX)
                    count = TW.MaxCols;
                else
                    count = min(TW.MaxCols, (int)LOWORD(BufBytesRemaining));
                /* send it to the port */
                WriteToPort(cid, tbuf, count);
                GB.lBufHead += count;
                BufBytesRemaining = GB.lBufTail - GB.lBufHead;
                GlobalUnlock(GB.hBuf);
            }
            if (BufBytesRemaining <= 0)
                GB.hBuf = GlobalFree(GB.hBuf);
        }
    }
}
```

2

NOTE: *This is only a sample portion of the code available for this article. Complete listings are included on this issue's code disk or from our BBS services. See pages 8, 88 & 95 for more information.*

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COBOL Comes of Age

by
Richard Riehle

COBOL was introduced in 1959, before we had formal notions of "structured programming" or "top-down design." Early COBOL programmers were practical people with no training in computer science theory and very little precedent. However, they did get the job done in industries as diverse as insurance, banking, automotive manufacturing, retailing, and public utilities. Consequently, COBOL remains the language of choice for much business data processing—but not without progress *and* change.

For starters, computer science graduates from universities in the 1970s used Pascal or PL/1 as their principal language. In response, many of the graying, '60s programmers—some now elevated to loftier management positions, such as MIS directors and programming managers—began to dig in their heels, resisting any idea of improving their beloved COBOL. Still, the Pascal invasion was inexorable; devotees of structured programming began to exert greater and greater influence. Next, CODASYL (Committee on Data Systems and Languages) in 1981 proposed a new COBOL standard based on radical new ideas of programming . . . well, ideas that seemed radical to many old-guard COBOL practitioners.

Present-day users of Pascal, Modula-2, Ada, and C will find familiar ideas in COBOL-85. New features include in-line loops (equivalent to "while ... do" and "repeat ... until"), scope terminators for conditional statements ("if ... end-if"), local and global variable declaration, called subprograms, a case statement, parameter passing between called procedures, and other features we have come to accept as de rigueur in most modern languages. Some of you might look back over the preceding list and ask, "How could they even write programs at all?"

Let's take a look at some of the new COBOL-85 constructs. We shall make most of our comparisons to COBOL-74, the previous ANSI standard for COBOL.

Iteration

Most production programs are fundamentally large loops containing many smaller loops. In "traditional" COBOL, one of the main looping constructs has been the PERFORM. The syntax (simplified) has been

```
PERFORM procedure name UNTIL condition
```

Somewhere in a COBOL program a procedure must exist that can be referenced by the PERFORM. The COBOL-85 enhancement permits an in-line loop, delimited by a scope terminator (END-PERFORM), that looks like this:

```
PERFORM UNTIL condition
   some procedural statements
END-PERFORM
```

All the statements between PERFORM and END-PERFORM will be executed exactly as if they had been coded in a procedure in some distant part of the program.

But this type of loop is still very limited. The developers of the COBOL-85 standard decided to provide a PERFORM variation that behaves like the well-known "while ... do" loop. The syntax is

```
PERFORM
   WITH TEST BEFORE
        UNTIL condition
   some procedural statements
END-PERFORM
```

The phrase WITH TEST BEFORE indicates that the loop should not be performed unless the condition tests true prior to each pass. In place of WITH TEST BEFORE, the programmer may use the expression WITH TEST AFTER, which forces the loop to complete at least one pass before terminating.

Users of modern programming languages take in-line loops for granted. Some old-time COBOL programmers fail to see the advantage of being able to do a PERFORM without specifying a procedure to PERFORM. However, the advantage of a "while ... do" construct clicks into place fairly quickly with most experienced COBOL programmers.

Selection

Standard COBOL has had one fundamental statement for selection: "IF ... ELSE"—the subject of controversy and argument in COBOL circles. You would think every COBOL veteran would welcome some improvement; many have, but some still miss the point. In traditional COBOL, we have

```
IF condition  [ do something ]
ELSE          [ do something else ]
```

Sometimes we have nested statements:

```
IF condition-1          NOTE: There is no
     [do A]                   "do" statement
   IF condition-2             in COBOL.
      IF condition-3
         [do B]
      ELSE
         [do C]
   ELSE
      [do D]
ELSE
    [do E].
```

The nested IF has created fascinating maintenance problems—even the original coder sometimes is unsure about what was really intended. Some COBOL programming managers simply prohibit the use of nested IF statements. Others complain that one cannot avoid using the evil GO TO unless one uses nested IFs. Attempts to correct errors resulting from nested IF statements often propagate still more errors.

To remedy this situation, COBOL-85 has introduced the previously mentioned scope terminator, which is used for all

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conditional statements in COBOL-85 programs. For an IF statement in COBOL-74, we have

```
IF condition THEN
    [do something]
ELSE
    [do something else]
END-IF
```

In COBOL-85, we would have

```
IF condition-1
     [do A]
     IF condition-2
         IF condition-3
             [do B]
         ELSE
             [do C]
         END-IF
     ELSE
         [do D]
     END-IF
ELSE
      [do E]
END-IF
```

The difference is subtle—but significant—when examined in the context of the elementary structures described by Jacopini and Bohm (see sidebar, "The Structure Theorem"). Experienced COBOL programmers will notice that I omitted the period after the final END-IF. In COBOL-85, the scope terminator is used instead.

Other elementary conditional COBOL statements have also been updated. One of the most significant changes concerns the READ statement. Prior to COBOL-85, READ was coded as

```
READ file-name
     AT END
         [do something].
```

With COBOL-85, we have

```
READ file-name
     AT END
         [do something]
     NOT AT END
         [do something else]
END-READ
```

Again, notice the elimination of the delimiting period found in prior incarnations of COBOL. The above statement might be coded as follows:

```
READ ACCOUNTS-FILE
     AT END
          PERFORM LAST-ACCOUNT-RECORD
     NOT AT END
          ADD 1 TO ACCOUNT-RECORD-COUNT
```

The Structure Theorem

Before the advent of "structured programming," certain styles of program organization were dubbed "spaghetti code" because of the many threads of logic in the code and the manner in which it often doubled back upon itself. Debugging such code was like trying to remove the sauce without disturbing the noodles.

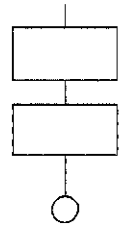
A solution to this problem came in 1966, when two European computer scientists, Bohm and Jacopini, published a paper proving that any correct program could be constructed using elementary structures. Their work is often referred to as the "structure theorem." Written in Italian, the paper remained unread in the English-speaking world for a long time, only beginning to receive accolades for its brilliance in the mid 1970s. Even now, though, most people who talk of structured programming do not know of the supporting formal proof.

The current literature on the structure theorem describes three elementary structures: Sequence, Iteration, and Selection. Sequence is a simple list of actions. Iteration is a loop, and Selection is a decision made on the basis of testing for some condition or conditions. The diagrams below illustrate each of these.

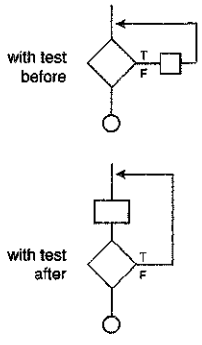
COBOL 85 has been updated to include each of these structures and make it possible to write correct programs on the basis of the structure theorem. This is one of the most important enhancements to COBOL since it was originally designed.

One special note: The little circle in each diagram represents a "scope terminator" and is implemented in COBOL-85 via the "END-" verb associated with most of the COBOL verbs. The scope terminator is an important element in correctly coding these structures.

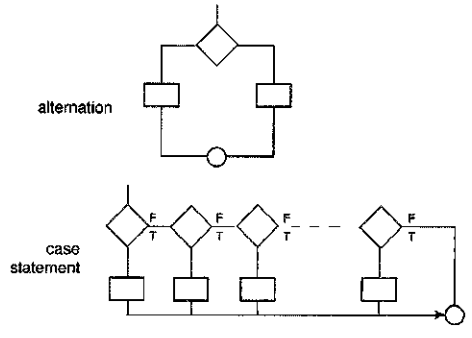
It seems especially fitting that two Italian computer scientists should have made such a significant contribution to the unraveling of spaghetti code. ♦



Sequence



Iteration



Selection

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```
          PERFORM ACCOUNT-UPDATE-ROUTINE
END-READ
```

If we were to enclose this statement in an in-line PERFORM as described above, we might have

```
001-MAIN-ROUTINE.
     PERFORM UNTIL END-ACCOUNTS
        READ ACCOUNTS-FILE
            AT END
                  PERFORM 005-LAST-ACCOUNT-RECORD
            NOT AT END
                  ADD 1 TO ACCOUNT-RECORD-COUNT
                  PERFORM 002-ACCOUNT-UPDATE-ROUTINE
        END-READ
                ... more program statements ...
     END PERFORM
     STOP RUN.
002-ACCOUNT-UPDATE-ROUTINE.
                  :
                  :
005-LAST-ACCOUNT-RECORD.
```

Another variation on the "selection" is the CASE statement. In COBOL-85 it is called the EVALUATE statement. Traditional COBOL has the following primitive implementation of the CASE statement:

```
GO TO ... DEPENDING ON variable.
```

When the GO TO fell into disrepute, so did GO TO ... DEPENDING. Moreover, GO TO ... DEPENDING was useful only for numeric data, much like the ON ... GOTO of BASIC. The EVALUATE statement has the following form:

```
EVALUATE [data name or statement]
    WHEN [condition]
         [do something]
    WHEN [condition]
         [do something]
    WHEN OTHER
         [do something]
END-EVALUATE
```

This construct is frequently used in place of the nested IF. Although EVALUATE seems to create less confusion than nested IF statements, some programmers create problems for themselves by not remaining alert to the scope rules. EVALUATE statements may also be nested, however, and that is where some of the problems occur.

Here is an example of EVALUATE within an in-line PERFORM:

```
 PERFORM UNTIL END-OF-FILE
    READ INVENTORY-MASTER
         AT END
            PERFORM END-OF-INVENTORY-MASTER
         NOT AT END
            ADD 1 TO INVENTORY-MASTER-RECORD-COUNT
            EVALUATE INVENTORY-TYPE
               WHEN  TYPE-A-ITEM
                     PERFORM ITEM-A-REPORT
               WHEN  TYPE-B-ITEM
                     PERFORM ITEM-B-REPORT
               WHEN  TYPE-C-ITEM
                     IF VALUATION > SMALL-VALUE-TYPE-C
                        THEN
                            PERFORM SMALL-C-REPORT
                        ELSE
                            PERFORM LARGE-C-REPORT
                     END-IF
               WHEN  FASHION-ITEM
                     PERFORM FASHION-ITEM-REPORT
               WHEN  OTHER
                     PERFORM ITEM-ERROR-REPORT
            END-EVALUATE
    END-READ
 END-PERFORM.
```

This code is not without its problems. For one, most programmers would create a separate paragraph for the code listed in the EVALUATE. If we named that paragraph VALIDATE-MASTER, the code would read PERFORM VALIDATE-MASTER.

Scope Control

The earliest versions of COBOL employed two main methods of scope control:

- Punctuation in the form of the period (.)
- The beginning of a new procedure

Thus, in our COBOL-74 example of a nested IF, we saw the scope span all subsequent IF statements until the final period. In our COBOL-85 example, we nested statements using the END-IF scope terminator.

COBOL-85 introduces about 19 new scope terminators. These control the scope of iteration, selection, and sequential statements. For example, in an ADD statement we have

```
PERFORM WITH TEST BEFORE
  VARYING DEDUCTION-INDEX FROM 1 BY 1
  UNTIL DEDUCTION-INDEX > 20
        ADD  DEDUCTION (DEDUCTION-INDEX)
             TO  TOTAL-DEDUCTIONS
                 ROUNDED
             ON  SIZE ERROR
                 SET DEDUCTION-INDEX TO 21
                 MOVE "X" TO TOTAL-DEDUCTIONS-ERROR-FLAG
                 PERFORM ERROR-JOURNAL-ROUTINE
             NOT ON SIZE ERROR
                 IF TOTAL-DEDUCTIONS
                   > MAXIMUM-ALLOWABLE-DEDUCTIONS
                     PERFORM EXCESS-DEDUCTIONS-ROUTINE
                 ELSE
                     PERFORM DEDUCTION-ALLOWANCE-ROUTINE
                 END-IF
        END-ADD
END-PERFORM
```

Or, in a MULTIPLY:

```
 MULTIPLY DISCOUNT-RATE BY PURCHASE
    GIVING DISCOUNT
         ON SIZE ERROR
            PERFORM DISCOUNT-SIZE-ERROR
         NOT ON SIZE ERROR
            ADD 1 TO DISCOUNT-OK
 END-MULTIPLY
```

Once again, it would be unusual to code an ADD statement as robust as the one shown above. Under COBOL-85, not only is such code allowed, but it is readable. This example also illustrates a practical use of the in-line PERFORM ... END-PERFORM construct: table handling.

In COBOL-85, scope terminators are defined for verbs that have a built-in exception-handling facility such as the READ, SEARCH, or arithmetic verbs. In addition, you have probably noticed that some of the exception conditions now have negation available.

Subprograms

We now come to a subject that is difficult for many experienced COBOL programmers to grasp immediately, a concept that is foreign to the COBOL way. COBOL-85 now has both local and global variable capability. We can even explicitly define global variables with the word GLOBAL.

For those of you new to this computer language, COBOL has always had all data globally available in a program region known as the DATA DIVISION. Each and every procedure statement anywhere in the program could access any data item in that region; there was no way to hide it. Thus, you always knew where the data was—somewhere in the DATA DIVISION. However, global variables also resulted in the unfortunate lack of capability to create truly modular programs.

COBOL-85 has remedied this situation by implementing an expanded CALL verb. Although CALL has been available in COBOL-74 (and IBM's mainframe version of COBOL-74 was especially powerful), COBOL-85 allows us greater power in creating nested COBOL programs and accessing them via a CALL. Each CALLed

Continued on page 89

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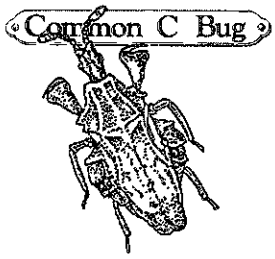

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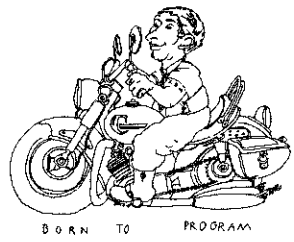

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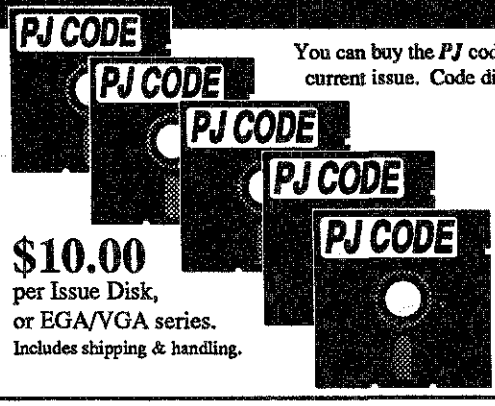

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program may contain its own local data names and procedures. The general form is

```
IDENTIFICATION DIVISION.
PROGRAM-ID. MAIN-PROGRAM.
          :
          :
DATA DIVISION.
WORKING-STORAGE SECTION.
01 WS-PARAMETERS.
   05 MAIN-PARM1          PIC X(04).
   05 MAIN-PARM2          PIC X(12).
PROCEDURE DIVISION.
          :
          :
     CALL SUB-PROGRAM-1
          USING MAIN-PARM-1,
                MAIN-PARM-2
          :
          :
IDENTIFICATION DIVISION.
PROGRAM-ID. SUB-PROGRAM-1 IS INITIAL PROGRAM.
          :
          :
DATA DIVISION.
LINKAGE SECTION.
01 LINK-PARAMETERS.
   05 LINK-PARM1          PIC X(04).
   05 LINK-PARM2          PIC X(12).
PROCEDURE DIVISION
          USING BY CONTENT LINK-PARM1,
                           LINK-PARM2
          :
          :
EXIT-PARAGRAPH.
        EXIT PROGRAM.
```

In most implementations, the LINKAGE SECTION does not occupy storage space of its own. When SUB-PROGRAM-1 is CALLed by MAIN-PROGRAM in the above example, pointers are set up from the LINKAGE section back to the storage addresses of the corresponding parameters in the calling program. Although this is not quite as good as having separate storage areas for the named variables, it is better than what we have had in earlier COBOL.

The phrase "BY CONTENT" means that the parameters may not be modified in the storage area of the CALLing by the CALLed program. The default is that such values may be changed.

As in Pascal or FORTRAN, parameters are passed positionally; that is, the first parameter in the CALLing list must correspond in form and type to the first parameter in the USING list of the CALLed subprogram. When the subprogram CALL feature is combined with the COPY verb, designers have more capability for team programming on large projects. Each programmer can be working on a module independently of other members of the team. Even better, algorithms implemented for one project can easily be incorporated into new projects. For example, a compound-interest routine can be used over and over in many programs with no regard to the variable names. The programmer simply copies the routine into his or her program and CALLs it as a subprogram with appropriate parameters without being concerned with the underlying algorithmic implementation.

Some of you have read my article "Ada—a Software Engineering Tool" in an earlier article in *Programmer's Journal* (Volume 6.5, September/October 1988). COBOL subprograms implement some of the principles discussed in that article: information hiding, modularity, and localization. The hoped-for outcome is greater reliability, readability, modifiability, and understandability.

Optional Filler

One of my early COBOL acquaintances said that over 80 percent of the world is FILLER—clearly a pre-ecological observation. In COBOL-85, however, we can avoid the word FILLER when we choose to do so, without harmful effects. Therefore, the following:

```
01 MY-RECORD-LAYOUT.
   05 DATA-FIELD-1        PIC X(07).
   05                     PIC X(02).
   05 DATA-FIELD-2        PIC X(21).
   05                     PIC X(02).
   05 DATA-FIELD-3        PIC X(48).
```

is equivalent to

```
01 MY-RECORD-LAYOUT.
   05 DATA-FIELD-1        PIC X(07).
   05 FILLER              PIC X(02).
   05 DATA-FIELD-2        PIC X(21).
   05 FILLER              PIC X(02).
   05 DATA-FIELD-3        PIC X(48).
```

String Manipulation

One of the really frustrating elements of traditional COBOL has been its cumbersome string-handling capabilities. This function has been improved in COBOL-85 with features such as reference modification. Suppose we have string data defined as follows:

```
05 DATA-1    PIC X(12)   VALUE "ABCDEFGHIJKL".
05 DATA-2    PIC X(02)   VALUE SPACES.
05 DATA-3    PIC X(14)   VALUE "MNOPQRSTUVWXYZ"
05 DATA-4    PIC X(26)   VALUE SPACES.
```

We can do the following:

```
MOVE DATA-1 (7:2) TO DATA-2
```

with the result "GH" in DATA-2.

When this feature is used in combination with the STRING and UNSTRING commands already available in COBOL-74, we are able to do some powerful manipulation of string data. For example:

```
STRING DATA-1 DATA-3 INTO DATA-4
```

results in

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

in DATA-4.

New Level-88 Capabilities

The Level-88 condition names have been enhanced to allow "Boolean" operators TRUE or FALSE. Using an END-OF-FILE flag condition, we could have:

```
01 PROGRAM-CONDITIONS.
   05 END-OF-FILE-FLAG     PIC X VALUE "N".
      88 END-OF-FILE  VALUE "Y" FALSE "N".
```

In the PROCEDURE DIVISION, we would have:

```
OPEN INPUT ACCOUNT-MASTER-FILE
SET END-OF-FILE TO FALSE
PERFORM UNTIL END-OF-FILE
    READ ACCOUNT-MASTER-FILE
         AT END
              SET END-OF-FILE TO TRUE
    END-READ
END-PERFORM
```

Notice that the condition is altered with a SET command rather than with a MOVE.

The availability of a Boolean operator makes it possible to create COBOL decision structures that operate with greater clarity than before. In addition, selection statements, one of the elementary structures described by Bohm and Jacopini, are implemented more elegantly using Boolean operations.

Implementations

When COBOL was introduced in 1959, it was intended to be "open ended and capable of change and amendment." COBOL-85 is only the third revision to be approved by the American National Standards Institute (ANSI). Previous approved versions were COBOL-68 and COBOL-74. Many programming organizations still have not made the transition from COBOL-68 to COBOL-74. Some software developers provide source code with their products and keep the COBOL code compatible with all versions, including '68 and '74. These developers must decide what to do about COBOL-85. One

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premier software vendor in Sunnyvale, California, uses the same COBOL for all computer platforms—mainframe, mini, micro. Consequently, the company must employ the most generic and primitive features of the language and cannot take advantage of COBOL-85's new features. Conversely, an in-house developer, such as Wells Fargo Bank, is able to plan projects with all the new COBOL-85 features because it is not sharing code with other organizations.

In the COBOL world, many managers learned their programming on the job. As these executives moved up the management ladder, their attention became focused more on business decisions and less on technical ideas. In addition, many managers have well-justified paranoia about introducing new software methods. (Many COBOL shops still do not believe in "structured programming.")

COBOL-85 is just beginning to find its way into production projects. IBM, which introduced a variant of COBOL-85 (named COBOL II) in 1984, has recently released its version of COBOL-85 for its mainframes. Many smaller vendors, such as Hewlett-Packard, Digital Equipment Corp., and PRIME, have had a version of COBOL-85 available for several years. Microsoft's earlier introduction of COBOL was a real disappointment (I wrote a small hospital project using it). To its credit, Microsoft has upgraded its COBOL commitment and is now offering a good version of COBOL-85. Also in the microcomputer world, REALIA has a good COBOL-85 compiler. I just finished teaching a COBOL class using Tandem Computers, and I'm really impressed with Tandem's implementation of COBOL-85. Also, HP's COBOL-85 under MPE-XL is nicely done.

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The Future

As a programming language, COBOL has been criticized and praised; still, its future is bright. COBOL's new features make it useable for production programming under contemporary standards for software development. A huge literature exists in this language that a large number of programmers already know. One important characteristic of COBOL has always been its ease of learning and use. COBOL-85 makes it even easier. Moreover, college students in computer science programs are learning the kind of programming theory that is the very foundation of COBOL-85.

The strict program organization of COBOL makes it appropriate for use in environments that require adherence to well-defined standards. In addition, it can be used effectively by people with very little training or knowledge of computer science.

Manufacturers of computer equipment have made a commitment to on-going support of COBOL. Even with the advent of new methods of database management, COBOL has been able to keep up. In the IBM mainframe world, SQL and CICS are coded directly into the COBOL source code with statements such as EXEC SQL or EXEC CICS, where a COBOL preprocessor expands the embedded source code into statements useable by the COBOL compiler. IBM has gone even further with COBOL II (COBOL 85) and allowed its compiler actually to recognize the existence of CICS directly.

The language is not yet as good as it could be. My wish list includes a PERFORM statement that allows parameter passing, comments on the same line with executable code, additional exception-handling features, standard methods for on-line transaction processing, user-defined verbs, and greater subprogram independence. Still, the current definition for COBOL-85 brings the language a long way toward creating better software systems. Not only do we have better tools, but we can build on knowledge gained from the successful COBOL systems of the past. ♦

Richard D. Riehle is an instructor in Ada at Merritt College in Oakland, and Foothill College in Los Altos, California. He is also an independent computer consultant. Mr. Riehle's training organization ICE (for Intensive Computer Education) conducts seminars on a variety of computer subjects. Mr. Riehle has over twenty years in software development, including design, programming, and project management. He is currently working on a book, From COBOL to Ada, *a tutorial for experienced business programming professionals. Readers may contact Mr. Riehle at 1090-105 Tanland Drive, Palo Alto, CA 94303, (415) 858-1267.*

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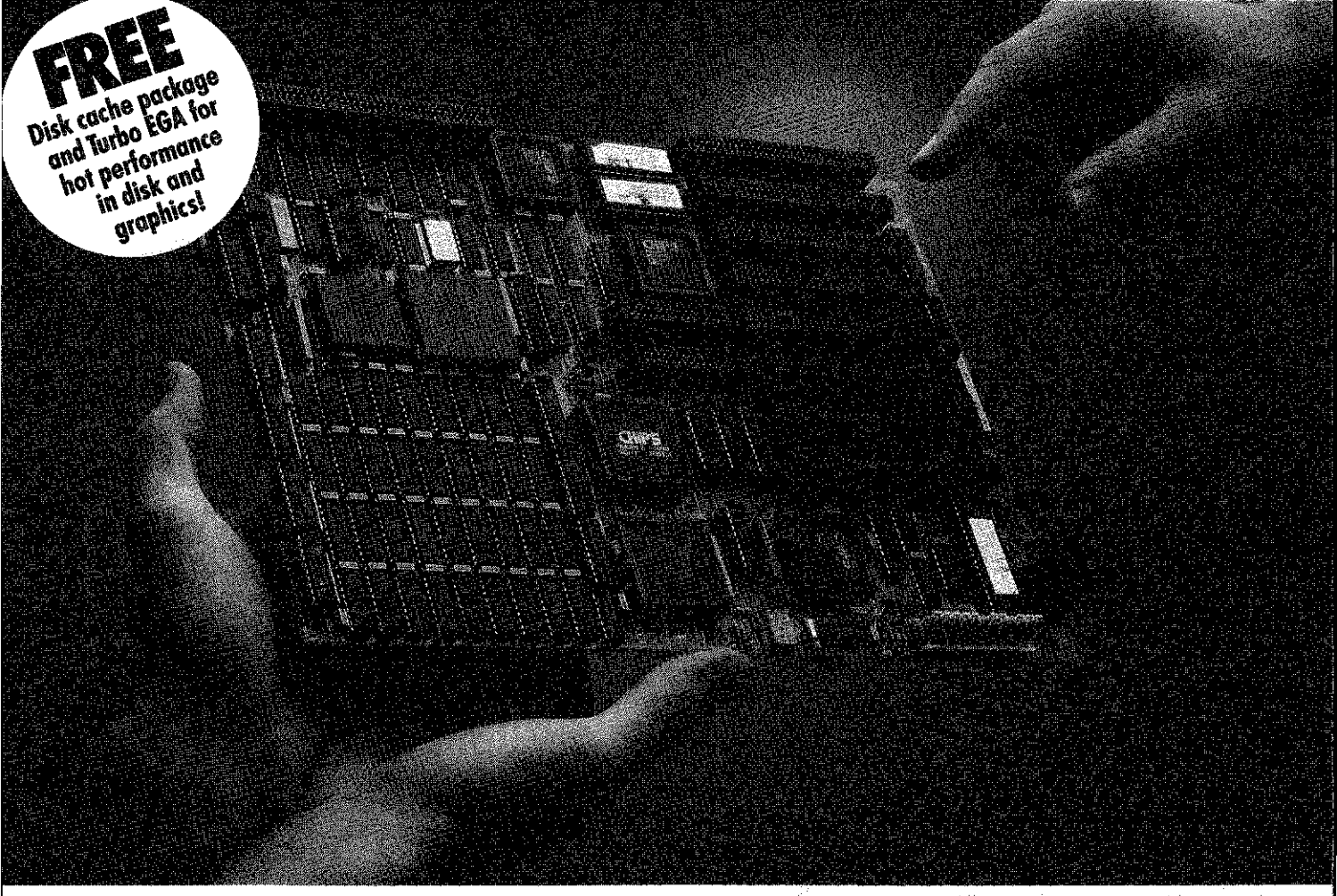

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Programming Utilities

OPUS Make 5.1
OPUS Software
1032 Irving St., Suite 439
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(415) 664-7901

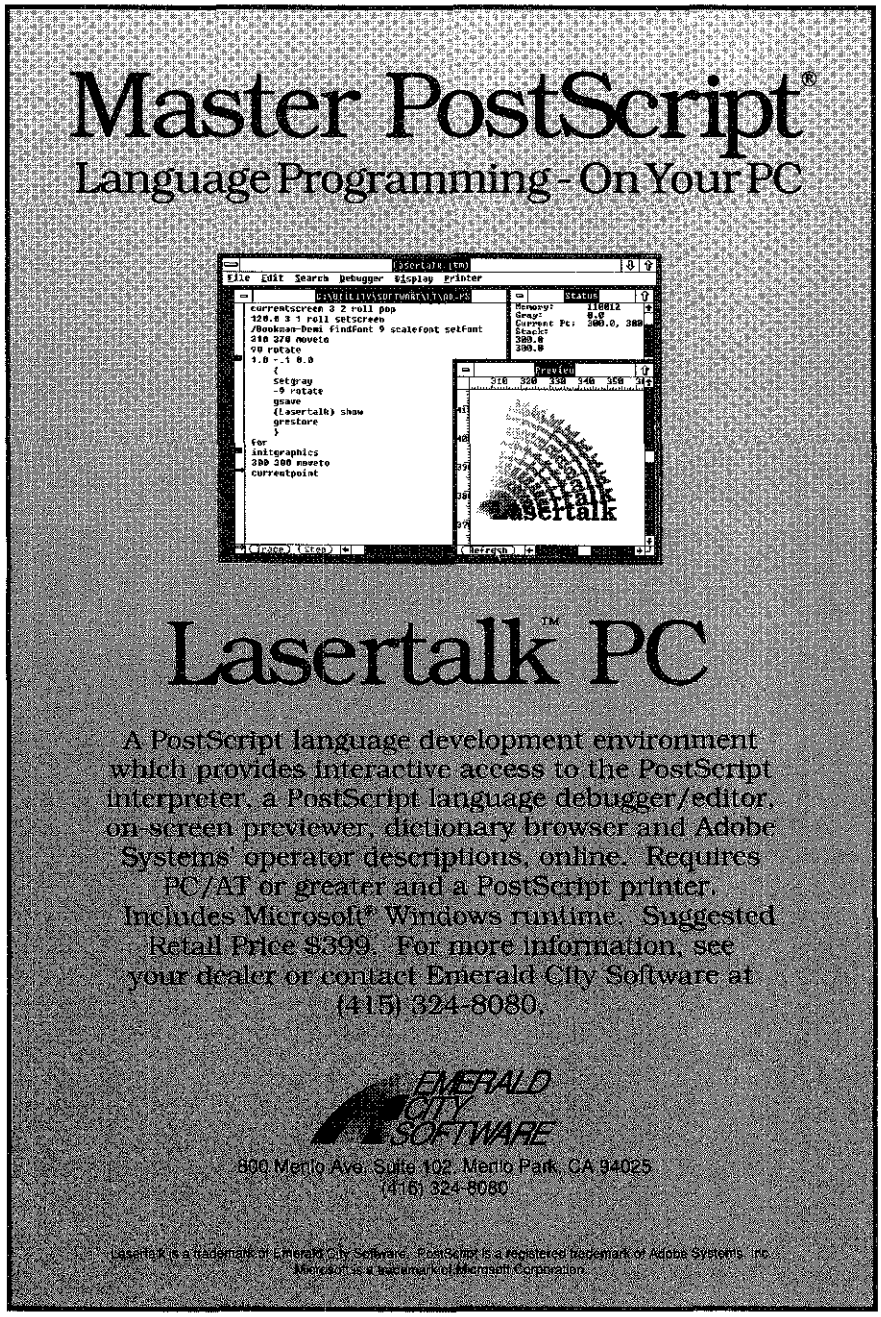
Continuing our look at make utilities, I've received a fine new product, OPUS Make Version 5.1. The OPUS Make package ($79) includes two versions of make for both DOS and OS/2 (small and large models), a program to create make dependency files, and several useful utilities. OPUS Make supports the Unix make dependency language with enhancements and extensions. OPUS Make executes quickly and under DOS supports an attractive memory-miser option. Rather than creating batch files, OPUS Make reduces the amount of memory it uses to a minimum by paging itself out. With this option, OPUS Make will extract less than 3K of overhead when executing your favorite compiler or linker yet still maintain full control. Another memory-reducing option is a one-command mode, which executes only one shell line from a makefile. This option is useful for doing compiles from inside editors, since it spares the overhead of paging, but it still reduces memory usage to about 1K. These features are unnecessary under OS/2.

OPUS Make supports 17 command-line options to control operation. Options may also be set via a predefined macro MFLAGS in a makefile or via an environment variable. These options include a directory snapshot feature to speed make execution; the DOS memory-miser features; a Microsoft compatibility mode; the ability to disable default inference rules, give environment macros higher precedence, and print information on macros, dependencies, and inference rules; and a debug/trace mode.

The Unix dependency file syntax has been extended with powerful loop and conditional directives similar to the C language. These directives begin with the ! character, much like extensions added by Borland to their make program. These directives support if, else, elif, endif, while, foreach, break, continue, end, include and error constructs. A rich set of predefined macros is provided. A VPATH macro specifies additional directory names to find files that don't have a path specification. Two special targets are supported: .BEFORE and .AFTER, which would be executed on initialization and after the Make process has been completed. This feature can be especially helpful in setting up an environment for different build processes and restoring the state at the process end. Other pseudotargets support the Polytron Version Control System logfiles; the creation of response files for Microsoft LINK, LIB, and other programs; control-C handling, and the issuance of warnings when using undefined macros.

Default inference rules are read at start-up from a MAKE.INI, if one exists. These default rules may be readily changed to support your current compiler/linker and build process. Under DOS, multiple commands in a single shell line are supported, separated by semicolons. File I/O redirection is supported for both stdout and stderr.

The package includes MKMF, a tool for generating and managing makefiles from user-defined templates. Dependency information is computed by scanning source files for included files. MKMF recognizes standard filename suffixes for C, C++, Pascal, FORTRAN, and assembler and can be extended. This utility works best for C and C++ files by understanding C preprocessor directives. Support for other languages is much weaker because of the limited "include" syntax supported. A useful TOUCH utility is also supplied to update files' date/time stamps or change them to some arbitrary time. The manual is on the terse side (47 pages—with no index—plus a 4-page addendum) and could clearly benefit from more examples. A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limited set of sample makefiles is provided, which could be enhanced with examples for compilers other than Microsoft and different languages. But if you are used to the Unix make syntax, OPUS Make appears to be a solid product.

BASIC Utilities

QuickPak Professional
Crescent Software
11 Grandview Avenue
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Over the last two years, I've witnessed a strong resurgence in popularity of BASIC. Clearly, the original PC language is learning some new tricks with fast new compilers from Microsoft and Borland. Crescent Software has released QuickPak Professional ($149), a comprehensive set of tools and utilities for BASIC programmers. The package consists of over 300 routines callable from BASIC, along with several dozen demonstration programs. Most of the routines are written in assembly language for speed and reduced size. The current release is available for use with Microsoft QuickBASIC 2, 3 and 4, BASCOM 6, and Borland's Turbo Basic. Complete BASIC and assembler source code is also provided.

All of the QuickBASIC 4 (QB4) data types are supported, including fixed-length and TYPE variables. The package includes extensive routines for DOS services (58), array functions (25), string manipulation (12), parsing and type conversion (17), scientific and financial functions (32), keyboard and mouse support (26), pull-down menu and input support (16), window management and video services (41), and numerous miscellaneous routines (49). A full set of file and printer routines is provided, eliminating the need to use BASIC's ON ERROR statements, with savings in executable file size and increased runtime speed. File and string encryption are supported, as are file and record locking. Screen dumps are supported in all graphics video modes to various printers. The video routines support multiple screen pages and EGA/VGA 43- and 50-line modes automatically.

The package also features a series of applications that may be added to your BASIC programs. These include a complete spreadsheet program; a full-screen editor with word wrap, block operations, and mouse support; a pop-up calculator; a calendar; an ASCII chart; and a file browser. The package comes on four disks, one with assembly language source. I found the BASIC and assembler source code files well documented, with extensive comments for use as a learning tool.

The documentation included is very extensive. The main QuickPak manual has more than 400 pages and contains a general discussion of the package, a separate page or two describing each function in detail, and a tutorial. Each routine is documented with a

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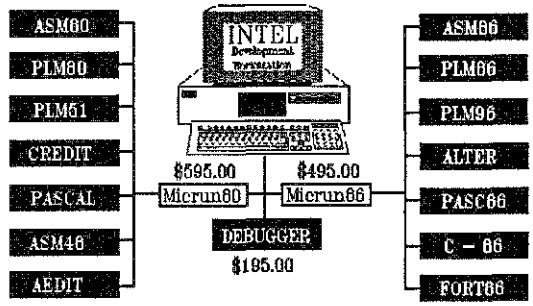

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brief description (purpose), variable description and syntax for both QuickBASIC 4/Bascom 6 and QB2/3/Turbo BASIC, an example of its use, and comments. The general sections describe software installation and use and provide a tutorial on passing variables to BASIC functions, linking with the supplied libraries, and building the libraries from the supplied assembler and BASIC source files. The appendix also functions as a tutorial, comparing various BASIC calling mechanisms (CALL, GOSUB, and multiline functions), random files, dynamic versus static arrays, long integers, and problems and pitfalls. In addition, a separate 60-plus-page tutorial is supplied for working with assembly language and BASIC. This tutorial is written in a light, humorous, and easily readable style. Unfortunately, neither of these manuals has an index.

I can heartily recommend QuickPak Professional to both the beginner (for its extensive tutorials) and the professional (for its breadth and depth of utilities). Upgrades from earlier QuickPak releases are available at nominal cost. Crescent Software also sells GraphPak Professional ($149)—a BASIC library of charting and graphics subroutines, LaserPak Professional ($149)—a set of BASIC subroutines for controlling HP Laserjet and various dot matrix printers, and other BASIC support products. Their QuickTALK catalog is published as an attractive typeset magazine, with articles and BASIC programming tips along with information on their products.

Standards

GOSIP
National Bureau of Standards (NBS)
B154 Technology
Gaithersburg, MD 20899
(301) 975-3240

For years, the TCP/IP protocols developed and supported by the Department of Defense have been the de facto standard for internetworking computers in government, military, and many private organizations, particularly among Unix machines. After a long-term effort supporting the open systems interconnect (OSI) networking standards development, the US government is finally moving ahead to implement the concept. The vehicle for this action is the recently adopted Government Open Systems Interconnection Profile (GOSIP)—don't you just love those acronyms?

GOSIP defines a common set of data communication protocols to enable systems developed by different vendors to interoperate and enable users of different applications on these systems to exchange information. GOSIP is based on the OSI protocols developed by the International Organization for Standards (ISO) along with agreements reached by the NBS and various vendors over the last two years. OSI defines a seven-layer network (cake) protocol. The GOSIP standard was officially approved in August 1988 and becomes effective in February 1989.

This standard mandates that new computer network products and services acquired by federal agencies must support GOSIP (OSI functionality). Currently, GOSIP supports Message Handling Systems and File Transfer, Access, and Management applications (FTAM). GOSIP also supports interconnection of the following network technologies: X.25; Carrier Sense Multiple Access with Collision Detection (CSMA/CD)—Ethernet and IEEE 802.3; Token Bus—IEEE 802.4; and Token Ring—IEEE 802.5. Starting in February 1989, agencies will be "encouraged" to acquire GOSIP-conforming new products. After 18 months, this will become a mandatory requirement in solicitations and contracts. Agencies also will be permitted to buy network products in addition to those specified in GOSIP. Both TCP/IP and OSI will likely coexist for some time on government networks.

NBS is offering the free publication *GOSIP Version 1.0* (June 1988), describing the sources of the protocol specifications, conformance, interoperability, performance testing, brief protocol descriptions, network addressing requirements, and security options. The detailed protocol specifications are contained in *Stable Implementation Agreements for Open Systems Interconnection Protocols* (NBS Special Publication 500-150). This document can be purchased for $12 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; phone (202) 783-3238. Specify stock number 003-02838-0. ♦

USENIX and C++

by Vaughn Vernon

Until recently, learning C++ from the available publications was like trying to learn a foreign language from a Berlitz pocket guide. All of the right stuff is there (in minimal form), but for some reason you just can't stand the embarrassment of opening it and listening to yourself say those funny little words! Dunke shhh, what?

Fortunately USENIX, a nonprofit interest group of Unix users, has taken an active roll in promoting the C++ programming language. USENIX holds annual C++ conferences (last year's was in Denver). They also sell C++ Work Shop/Conference Proceedings from previous sessions in 1987 and 1988.

The Proceedings are 300 to 500 pages of leading-edge material on C++. The papers in these Proceedings are as important—or even more so— than the AT&T release notes on C++. For instance, the 1987 proceedings contain details on multiple inheritance (MI) in C++. MI is not yet available as part of a real product, and it may not be for a few more months. This presents two unique advantages to developers: First, you learn how to use a new feature well before it is available; second, you can warn C++'s designer and implementer, Bjarne Stroustrup at AT&T, of potential dangers before the feature is forever engraved in stone!

In any event, the conference Proceedings are the most up-to-date definition of C++. The Proceedings contain numerous case studies of C++ users and implementers as well as new tools designed to enhance C++'s usefulness and programmer productivity. I recommend that anyone having even a slight interest in C++ order both the 1987 and 1988 Proceedings.

The C++ conference itself is an invaluable four days of inspiring, intuitive sessions presented by the true experts in the field. The first two days are paid tutorials for newcomers. The conference itself is held on the next two days. A fifth day is devoted to implementers (only) of C++ translators and compilers.

Bjarne Stroustrup explains planned new features of C++ at the conference. In 1988, new features included Parameterized Types and Type-safe Linkage. Bjarne openly asks for constructive criticism of his ideas, which proves that he is indeed concerned about not introducing a faulty feature into C++ and forever infecting its users.

If I sound excited, it's because I am. The problem for many of you is that you will have to wait for 1989's C++ Conference. However, until then I urge you to get the C++ Conference Proceedings. Contact:

USENIX Association
P.O. Box 2299
Berkeley, CA 94710 USA

Proceedings: $20 per copy, prepaid. Phone orders are not available. Conference: $150 for two days. USENIX is a not-for-profit association. ♦

Vaughn Vernon is President of Aspen Scientific, makers of CURSES.

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Correction

In the MISCELLANEOUS section of the November/December 1988 *PJ* (Volume 6.6), the name of the Seidl Make utility and the name of its maker, Seidl Computer Engineering, were misspelled in the review. We apologize for the error.

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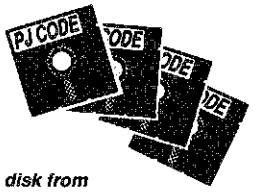

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A GP command sequence is like a program, but in a very simple language. You load a string of GP commands into the 82786 memory, terminate it with an NOP that has its ECL (End of Command Line) bit set, and then tell the GP to start executing from a specific point in memory. Since the chip does not have any conditional branch instructions, its programmability is severely limited. It does have CALL and RETURN commands, though; so you could set up a generic command list to, for example, draw a box with an *X* in it at the current *x,y* position and make it a subroutine that you could call in from your 82786 "program."

Table 1. Logical Writing/Pixel Processing Mode on the 34010 (The first 16 are also supported by the 82786.)

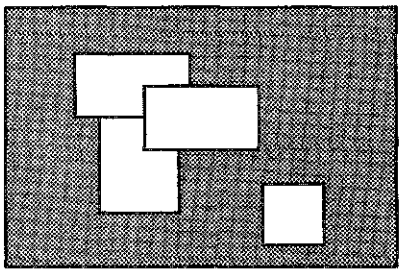
Definitions:

0s	All bits in the pixel are set to 0
1s	All bits in the pixel are set to 1
DST	The pixel at the destination
SRC	The source pixel
AND	Bitwise AND operation
OR	Bitwise OR operation
XOR	Bitwise XOR operation
NOT	Bitwise NOT (one's complement) operation
ADD	Unsigned Addition
SUB	Unsigned Subtraction
ADDS	ADD with Saturation (no wrap, max's out at max pixel value)
SUBS	SUB with Saturation (no wrap, stops at a pixel value of 0)
MAX	Larger of the two operands
MIN	Smaller of the two operands

The result of a pixel processing operation is placed in DST.

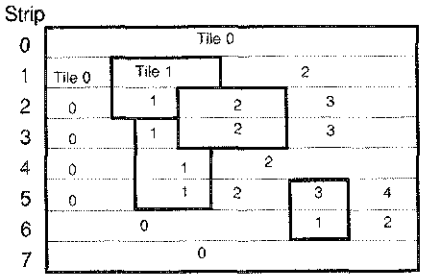
Processing Modes:

```
SRC
SRC AND DST
SRC AND (NOT DST)
0s
SRC OR (NOT DST)
(NOT SRC) XOR DST
NOT DST
(NOT SRC) OR (NOT DST)
SRC OR DST
DST
SRC XOR DST
(NOT SRC) AND DST
1s
(NOT SRC) OR DST
(NOT SRC) AND (NOT DST)
NOT SRC
SRC ADD DST
SRC ADDS DST
DST SUB SRC
DST SUBS SRC
MAX(SRC, DST)
MIN(SRC, DST)
```



Shaded area is field, i.e., not data.

What you see on screen, 4 hardware windows



Strip and tile breakdown of an 82786 screen

Hardware windows are similar in concept to the overlapping software windows utilized in such packages as Microsoft Windows. The big difference is that hardware windows do not require a redraw of screen information when the window is moved. This means that you can have virtually simultaneous drawing going on in a number of overlapping windows without worrying about clipping, because the hardware windows only display what's in memory; they do not alter memory. Hardware windows can also display *field*, a term used to indicate non–memory consuming display information ("dead space"). Because all normal limitations are removed, the long-time tie between memory and display is completely altered, requiring programmers to toss out everything they know about displaying PC-based graphics.

Of course, you can still use the one-to-one correlation between memory and display by creating a full-screen hardware window. Hardware windows are rectangular tiles that display data from memory at 1, 2, 4, or 8 bits per pixel. To top that off, a window can be flagged to indicate to the hardware that it should be zoomed. The zoom factor ranges from 1 to 64 in both the *x* and *y* directions. The screen position of a hardware window as well as the contents are determined by the DP display list. This display list consists of a series of strips, each of which contains a number of tiles. There is a limit of 15 tiles per strip, but no limit on the number of strips, providing each one is at least one scan line high.

Although the 82786 is a coprocessor, it does have three sets of registers that can be accessed by an external processor. One set belongs to the DP and is used for setting display frequencies, display list location, cursor pattern, and so forth. Another set belongs to the GP and contains information regarding the current drawing environment, such as *x,y* position, colors, and start of drawing area in memory. The last set of registers is the set containing the processor control. This set can be either memory

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Programmer's Journal
The Resource Journal for IBM Micro Programmers

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January 5, 1989

Dear *PJ* Reader:

As you've probably noticed by now, page 38 of the January/February 1989 *Programmer's Journal* is missing a column of text. Mistakes like this are easily and often blamed on "printer error." Well, this time it *wasn't* our fault: Our printer really did goof, and they are working with us to make it up to you.

Although SLR Systems is no doubt thrilled to have their ad appear twice in one issue, we're sure you would rather have the material from Jake Richter's article. Therefore, we are having the printer send you a copy of the corrected page on the back of this letter. (If it's not there, they are *really* in trouble.)

We apologize for any inconvenience this blunder may have caused you. If we're all lucky, however, you may have a collector's item on your hands: The issue may contain the last mistake you ever find in *PJ*. (I know . . . and pigs may learn to fly in 1989, too.)

Sincerely yours,

Robert E. Wanetick

Robert E. Wanetick
Managing Editor

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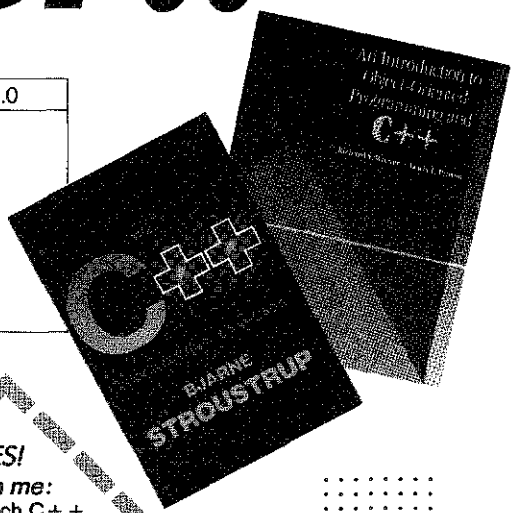
Performance benchmarks

Benchmark	Zortech C	Zortech C++	Turbo C 1.5	Quick C 1.0
Sieve	20.49	20.54	23.62	22.72
Rsieve	20.49	20.54	23.62	22.03
Integer	1.32	1.38	6.31	6.49
Float	0.17	0.22	52.29	51.03
*Float	32.73	37.74	52.39	51.63
Pointer	17.91	17.96	17.13	16.87
Rpointer	17.79	17.91	17.14	16.64
Loop	3.90	3.90	3.90	3.90
Optimize	0.49	0.60	8.46	8.79

Benchmarks were run on an 80286 based IBM compatible at 6Mhz with no 8087.

The float benchmark was re-run without optimization.



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Remote debugging	Yes	No
Data debugging	Yes	Partial
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Session logging	Yes	No
Conventional memory used—80386	Zero K	230K
Conventional memory used—remote	15K	N/A

Turbo Debugger version 1.0, Microsoft CodeView version 2.2.

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FEATURE COMPARISON	TURBO PASCAL 5.0	Turbo Pascal 4.0
Integrated debugger	Yes	No
Overlays, including EMS support	Yes	No
8087 floating-point emulation	Yes	No
Turbo Debugger support	Yes	No
Procedural types, variables, parameters	Yes	No
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Constant expressions	Yes	No
EMS support for editor	Yes	No

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